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CONTENTS

General Design and Research

Engineer and His Opportunity—C. F. Kettering 350
Alloy Steels and Their Application in the Automotive Industry—Dr. Birger Egeberg 362
Motor-Oil Characteristics—R. E. Wilkin, P. T. Oak and D. P. Barnard, 4th—(Discussion) 380
Independently Sprung Wheels—D. Sensaud de Lavaud—(Discussion) 385
Automobile Bodies from the Abstract Customer's Viewpoint—O. T. Kreusser 397
Automotive Research 405
Standardization Activities 421
Notes and Reviews 426

Production Engineering

Production Meeting Program Announced 349
Simultaneous Inspection and Correction of Gears in Production—Charles H. Logue and R. B. Fehr 371
Production Engineering 419

Operation and Maintenance

Excellent Transportation Program Arranged 348
Development of Profitable Fields of Motorcoach Operation—J. L. Smith 391
Operation and Maintenance 416

Aeronautical Engineering

Los Angeles Aeronautic Meeting 355
Naval Air-Tactics and Aircraft Design—Commander E. E. Wilson, U. S. N. 353
Supercharging for Sea-Level Conditions—C. Fayette Taylor and L. Morgan Porter—(Discussion) 359
Charles M. Manly Medal Award 409

News of the Society

Chronicle and Comment 352
Society Reorganization Proposed 410
News of Section Meetings 413
September Council Meeting 415
Personal Notes of the Members 424
Applicants Qualified 425
Applicants for Membership 425

The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

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Los Angeles Aeronautic Meeting

First East-West National Conference Devoted to Design, Production, Operation, Instrumentation and Standardization

PROBABLY no meeting of the Society ever held has been more beneficial as recording progress or more pregnant as promising needed developments than was the National Aeronautic Meeting held last month in wonderful California—where nothing is more wonderful than its advance in aeronautic technology and the marshalling, for work in aeronautics, of finely trained engineers and executives whose industry is fast reaching high rank in National activities.

The meeting was held during the week of the National Air Races, conducted under the auspices of the National Aeronautical Association, and of the National Aeronautic Exposition, managed by the California Air Race Association, at Mines Field, Los Angeles. Mines Field, located 10 miles from Los Angeles, was constructed especially for the event; what had been a barley field of 200 acres was transformed into an airport within two months. The main field of 120 acres was fenced, and a grandstand accommodating about 20,000 persons was constructed, in addition to a huge exposition-hall in which more than 200 exhibits of airplanes, parts, accessories and equipment were on view. A large portion of the field was sprayed with oil to keep down the dust.

Greatest Aeronautical World Gathering

Perhaps the world never has witnessed a larger asemblage of airplanes, pilots and engineers than on this occasion. While commercial aircraft were much in evidence, a very large part of the flying was done by Army, Navy and Marine Corps men. The formation and stunt flying, as well as the circuit races and the arrival of competitors from distant parts of the Country, including the East Coast, were greatly enjoyed by the huge crowds attending daily in numbers as high as 50,000.

The Aeronautical Chamber of Commerce and the National Aeronautical Association also held meetings during the week.

The greatest credit is due the California Air Race Association and its managing director, Cliff Henderson, for the very efficient and satisfactory arrangements for and the conduct of the exhibition and the races. The handling of the great crowds was excellent.

Reflected Quarter Century of Progress

As was pointed out by General Manager Humphries, of the Pacific Air Transport, at one of the S.A.E. sessions, only 25 years have elapsed since the Wrights made their first flight; 17 years since Earl Ovington flew the first air-mail from Garden City to Mineola, N. Y.; and 8 years since Edward Hubbard began operation of the first contract air-mail line, between Seattle, Wash., and Victoria, B. C. The conditions surrounding the various activities during the meetings and gatherings in Los Angeles last month were an exemplification of what has happened since those earlier days and a flowering into years of maturity and promise of great further accomplishment in aviation. This is particularly true in the case of the Society sessions, the purpose of these being to meet the needs of the conditions of air travel by the production of more efficient and dependable aircraft in quantities permitting greater and greater economy in first cost; at the same time standardizing construction and operation so far as this is rational; and inculcating practices in accord with best business principles.

S.A.E. Sessions Well Attended

The S.A.E. sessions, held at the Biltmore Hotel, were attended by more than 300 engineers and executives who reside in all parts of this Country and, in some cases, in foreign lands.

Not the least happy phase of the sessions was the very generous and efficient cooperation of Society members, including members of the Southern California Section of the Society, in arranging the program and conducting the sessions. The Meetings Committee was composed of Glenn L. Martin, Chairman; Edward P. Warner, L. M. Woolson, E. D. Osborn and Ethelbert Favary. This Committee was greatly assisted by the Committee on Local Arrangements, of which Mr. Favary was Chairman, the other members thereof being Donald A. Hall, W. D. Waterman, L. M. Griffith, C. F. Lienesch, Eustace B. Moore, William H. Fair-

Meetings Calendar

Transportation Meeting
Oct. 17 to 19, 1928, The Robert Treat, Newark, N. J.

Production Meeting
Nov. 22 and 23, 1928, Book-Cadillac Hotel, Detroit

Aeronautic Meeting
Dec. 5 and 6, 1928, Hotel Stevens, Chicago

Aeronautic Operation Meeting
January, 1929, New York City

Annual Dinner
Jan. 10, 1929, The Waldorf-Astoria, New York City

Annual Meeting
Jan. 15 to 18, 1929, Book-Cadillac Hotel, Detroit

Buffalo Section Meeting—Oct. 2, 1928
The Traffic Situation—Henry Seilheimer, district director, State Tax Department, in charge of motor vehicles

Chicago Section Meeting—Oct. 2, 1928
Automotive Engines—Clarence A. Peirce, chief engineer, Diamond T Motor Car Co.; and C. C. Hinkley

Cleveland Section Meeting—Oct. 8, 1928
The Place of Malleable Iron in Automotive Industry—H. A. Schwartz, manager of research, National Malleable & Steel Castings Co.
Section to be guests of National Malleable & Steel Castings Co., for trip through factory, dinner and paper

Detroit Section Meeting—Oct. 2, 1928
What the Public Knows about Engineering—R. H. Grant, vice-president in charge of sales, Chevrolet Motor Co.

Detroit Body Division Meeting—Oct. 22, 1928
Art and Color of the Automobile—Richard M. Bach, associate in industrial arts, Metropolitan Museum of Art

Indiana Section Meeting—Oct. 13, 1928
The Fuel Pump

Metropolitan Section Meeting—Oct. 25, 1928
Subject and speaker not announced

Milwaukee Section Meeting—Oct. 3, 1928
Manufacturing Processes and Characteristics of Electric Steel—Sidney Williams, metallurgist, Timken Roller Bearing Co.
The talk will be preceded by films showing the complete manufacturing process of electric steel

New England Section Meeting—Oct. 10, 1928
Fleet Maintenance—W. M. Clark, superintendent of transportation equipment, S. S. Pierce Co.—Prepared discussion by several fleet superintendents

Northern California Section Meeting—Oct. 11, 1928
Field Products Produced on the Pacific Coast—William Cohn, superintendent of plant, Columbia Steel Co.
The meeting will be held at Pittsburg, Cal. The Section members will be guests of the Columbia Steel Co. The speaking will occur during dinner; after dinner the Section members will visit the steel works

Pennsylvania Section Meeting—Oct. 9, 1928
Aviation Powerplants—Commander C. G. McCord, U. S. N., superintendent of tests, Naval Aircraft Factory

Southern California Section Meeting—Oct. 12, 1928
Drivers—Their Selection and Training—Operating Safety Measures—F. D. Howell, vice-president, Motor Transit Co.; F. C. Patton, assistant manager, Los Angeles Motor Coach Co.; and Ethelbert Favary, consulting engineer, Moreland Motor Truck Co.

banks, J. Jerome Canavan, and F. C. Patton. The members are greatly indebted to Mr. Favary, who worked for months on the preliminary stages of the occasion. Likewise, Assistant Secretary of the Navy Warner, who took a leading part in arranging the program of the meeting, also participated very helpfully in the conduct of all of the sessions.

Sincere thanks are extended to those who presided at the sessions and to those who presented papers and discussion.

Air-Lines and Weather Reporting

Qualified Personnel, Thorough Inspection and Servicing, and Ample Weather Reporting Necessary

THE Passenger Transportation Session was convened on the morning of Sept. 11, with Mr. Favary in the chair.

Hal Shields, general passenger agent of the Western Air Express, presented a paper on Selling Aircraft Transportation. He said that air transportation of passengers is in its infancy and that the passenger agents of air-lines are all studying intently the new field of work in which they are engaged, each endeavoring to profit by the success or failure of others.

Referring to the freedom from accidents on regular established commercial air-lines, Mr. Shields asserted that in the operations of the Western Air Express, which have been maintained between Los Angeles and Salt Lake City since April, 1926, no passenger or pilot has been injured in any way; also that the line from Los Angeles to San Francisco, which has been in operation for four months, has a substantially perfect on-time record. He is of the opinion that in this Country the rates of fare will be decreased before long, approaching the tariffs of European air-lines, which are not much in excess of railroad fares. He said that a profit can be made with 75 per cent average passenger-load.

More than 100 adjustments and inspections are made on each plane before it takes off. At present the upkeep costs are segregated for planes and for engines, the basis being flying hours and not ton-mileage. Engines are overhauled completely after every 300 hr. of operation, on the average. All pilots employed by the Western Air Express have been in Army or Navy service and received honorable discharge therefrom. Likewise, no mechanics are employed unless they have served in the Army or the Navy and been honorably discharged.

Weather-Report Stations Needed

H. R. Byers, of the Daniel Guggenheim Fund for the Promotion of Aeronautics, told of extremely interesting and valuable experimental work that is being conducted for the purpose of demonstrating the feasibility and value of systematic comprehensive weather-reporting, with the hope that the Government will soon establish permanently such a system. In Mr. Byers' opinion, the possibilities are unlimited.

The Guggenheim Fund, through its committee on meteorology, of which Dr. Carl Gusstaf Rossby is chairman, has established an experimental meteorological service on the San Francisco-Los Angeles Airway to serve as a model for future work. With adequate weather-reports available, said the speaker, efficiency of operation of airplanes, as well as safety, can be assured. It is understood that the experiment made is the first attempt to cope in this connection with the rapid advance of air travel in this Country. Air-lines are operating here today without proper weather-reporting service, reports from only a few stations along the routes flown being received. Owing to lack of sufficient appropriations, the United States Weather Bureau has concentrated its airway stations along regularly lighted airways; and even this installation is restricted to the relatively few more important routes. The result is that air-transport companies are compelled to resort to the inadequate weather-reporting systems they can themselves devise.

A Network of Stations Required

A string of weather-reporting stations does not offer adequate protection against unexpected bad weather; nor does it enable a pilot to know his way over an alternative route when the usual courses flown are dangerous. In some cases, local disturbances are encountered as complete surprises to pilots. In Mr. Byers' opinion, reports at regular intervals are necessary; if observations are taken at hourly intervals, the direction and speed of thunderstorms can be determined exactly. Also, the meteorologist can inform the pilot that, by the time of his arrival at a point where there was a storm, the bad weather will have "moved along."

The chief element the aviator must combat is fog. A network of stations alone can adequately report fog conditions. Few weather phenomena are as variable in character as those of fog. There should be a large number of stations, forming a dense net, in foggy and stormy areas, all of these stations taking simultaneous observations at regular intervals. This method alone will meet properly the needs of rapidly developing air transportation.

The Guggenheim Fund Model

In the network model established by the Guggenheim Fund, the stations extend, not only along, but for a considerable distance on either side of, commercial airways. They are located closely together all the way from San Francisco to Los Angeles in a zone extending from the Pacific Ocean to the foothills of the Sierras. There are 33 stations in all. Reports are collected by long-distance telephone at four points, these stations being equipped with printer-telegraph apparatus operated over a special leased wire. Observations are made at 90-min. intervals simultaneously at all stations. The collecting and exchanging of data by the four stations requires from 15 to 20 min. There are also several upper-air stations. Moreover, pilot-balloon observatories have been installed. Thus pilots can secure complete data as to wind direction and velocity at various levels along the route. Upper-air data are also secured from mountain stations. Mr. Byers said that in general the character of the observations is excellent. The observatories must provide information on clouds, ceiling and visibility.

Experimenting with Direction Finding

In this investigation no arrangements have been made for giving planes flying in fog their course and direction. Elsewhere the Guggenheim Fund is conducting experimentation in this connection. It is desired that airplanes shall be equipped with radio-receiving sets, by means of which they can secure complete reports of weather conditions. The system of ground-signals now being conducted, as outlined by Mr. Byers, has worked fairly satisfactorily; but as yet there is no practical method of guiding a pilot through fog, although it is stated that on the air route to Croydon, England, pilots in fog receive from the ground reports of their exact position. The direction-finder at Croydon is essentially different from the radio-beacon system used in this Country; it is similar to the type of radio lighthouses now operated by the Navy in this Country.

The British radio direction-finding stations are located along the coast; two stations receiving messages from the air connect with each other, take a cross-bearing, plot the angles on a chart, and compute the position of the airplane. Edward P. Warner said that he understood that the process may not require more than 75 seconds from

the time of the first signal until the pilot is notified of his position.

In the Guggenheim Fund work which Mr. Byers outlined the principal things to be observed as being of importance to the pilot are visibility and ceiling. There are no practical instruments for recording these automatically.

Air-Line Operation

A. K. Humphries, general manager of the Pacific Air Transport Co., contributed an excellent statement of the airplane operation by his company between Los Angeles and Seattle. The Pacific Air Transport contract was the eighth contract awarded by the Post-Office Department. Its route was unique in that it was the longest contract air-mail line in the Country, and the only privately operated line that attempted night-flying. Its pilots aided greatly in pioneering night-flying, developing it, in Mr. Humphries' opinion, to a greater degree than elsewhere in the world.

Great strides have been made in the last year in air transportation on the Pacific Coast. Now four large companies, in addition to the Pacific Air Transport Co., carry passengers; namely, the Western Air Express; the Maddux Air Lines, operating between Los Angeles and San Francisco; the Union Air Line, San Francisco to Seattle; and the Boeing Air Transport, San Francisco to Chicago. The Pacific Air Transport serves all major cities on the Pacific Coast with air mail, passenger and express transportation.

As to pilots, Mr. Humphries said that a good pilot must have had many years of experience, with primary training secured in military aviation. He should have spent three to five

Prominent Participants at the Passenger Transportation Session

Ethelbert Favary (Center), Who Served as Chairman of the Opening Session, Was Largely Responsible for the Los Angeles Aeronautic Meeting, Having Served as Member of the S.A.E. Aeronautic Committee and as Chairman of the Local Committee. (Upper Left) Hal Shields, General Passenger Agent of the Western Air Express, Who Spoke on the Selling of Passenger Transportation; (Lower Left) Charles H. Dolan, Jr., of the I. I. Steam Navigation Co. of Honolulu, and (Lower Right) Captain Stanford E. Moses, of the Airport Engineering Co., Who Took Part in the Discussion. (Upper Right) H. R. Byers, Meteorologist, with the Daniel Guggenheim Fund for the Promotion of Aeronautics, Who Presented a Paper, Prepared Jointly with Dr. C. G. Rossby, of the Massachusetts Institute of Technology, on the Future of Air Transportation from a Meteorological Viewpoint

years in commercial flying, in all kinds of cross-country flying, under severe and changing weather conditions. He should be, preferably, a college man, and of "unerring" judgment. A good pilot's income amounts to from $6,000 to $10,000 per year.

Mechanics favored by air-transport companies are usually men who are rather slow but never leave a job partly done; each job must be finished completely, with every bolt and cotter-pin secure.

Field managers have full charge of equipment on the field; they are charged with the duty of making decisions as to flight under adverse conditions. The importance of the work of these men is increasing from day to day. It is necessary that they have ability of a high type, with good educational background.

Inspection and Servicing

Proper surveying and inspecting of airplanes is vitally important, asserted Mr. Humphries. The possibility of trouble due to defects must be detected in advance. Every part of a plane must be gone over searchingly after a few hours of flight. The plane should be under inspection on the ground longer than the time it is in flight. Engines must be thoroughly overhauled after 200 hr. of service; all parts being inspected for wear and parts not up to standard being replaced. Propellers must be balanced and checked frequently. If the smallest crack is detected in a propeller, the propeller should be immediately discarded. Coincidently with engine overhaul, all instruments should be thoroughly checked. In the Pacific Air Transport Co.'s service, motor-cars capable of a speed of 85 m.p.h. are maintained for transporting mail from Los Angeles to Bakersfield during weather conditions that are unduly adverse to air travel.

As to the servicing of airplanes by the use of modern automatic pumping equipment, 5 gal. of oil and 100 gal. of gasoline can be put on board within 10 min.

Soon airplanes will be directed in the air by radio communication from the ground. Radio operators must have good general knowledge of operating and flying conditions.

Three methods of communication have been found most efficient by the Pacific Air Transport Co.: first, radio; second, telephone-typewriter, which transmits messages over telephone wires; and, third, the telephone. Ordinary telegrams are out of the question, as machines arrive at destination before the telegrams are delivered.

The cost of airplane operation is much greater than is realized generally. The greater the distance over which operations are conducted, the greater the investment must be.

Standardization Important

Savings to Aircraft Builders by Prompt Adoption Foreseen —Problems of Aircraft Lighting

At the Standards Session on the afternoon of Sept. 11 Edward P. Warner, Chairman of the Aeronautic Division of the Standards Committee, who presided, outlined the work the Society is attempting in aeronautic standardization. Commenting on the opposition to standardization that has sometimes been met, he called attention to the benefits to be derived and pointed out the fallacy of the belief that research work and independent design would be hampered.

Mr. Warner said that interchangeability, in the interest of ease of maintenance, of convenience and of replacement far from home, can proceed only from mass production of standardized articles.

In the first paper of the session, entitled What the Aeronautical Industry Can Learn from Automobile Standardization, C. F. Clarkson, General Manager of the Sociey, outlined the progress which has been made in transportation methods.

No industry has been more active or produced more standards than has the automobile industry, he said. Standardization of the right type is in no sense stagnation; it must always be subordinate to progress and design. Standardization does not impede necessary change but facilitates the making of needed changes economically. It decreases the original cost and the cost of scrapping special designs, which must of necessity be relatively expensive.

The present condition of very satisfactory prosperity in the automobile industry is due in a large part to the action of its far-sighted pioneers, who foresaw the advantages of standardization.

By means of curves, Mr. Clarkson reviewed the work of the Society in automobile standardization, including the number of revisions and cancellations of standards. The activity of the Society in aeronautical standardization was outlined, attention being called to the fact that of the 260 specifically denominated automobile standards published in the S.A.E. Handbook, approximately 100 relate to aircraft parts and materials.

To the adoption of the standardization policy in the automotive industry is largely due the achievement of the American car in its present internationally dominating position.

It has been estimated by a large group of engineers that, had not the S.A.E. standards been developed, the price of the present-day automobile would be at least 15 per cent greater than it is. There is every reason to believe that similar advantage can be gained by the aeronautic industry, provided the work of standardization in its field is taken up sufficiently early in a comprehensive way.

Viewpoint of a Manufacturer

The attitude of an airplane manufacturer toward standardization was presented in a paper prepared by W. C. Naylor, chief engineer of the Stinson Aircraft Corp. He stated that some aircraft manufacturers are not in a position to adopt many standards immediately, but that it is advisable for all to adopt as many as possible at the present time and, as occasion warrants, to develop others to meet new requirements.

He expressed the opinion that ultimately standardization of construction methods must be formulated to replace the present methods used in making welded-steel-tube fuselages. It is his belief that more standardization work can be done on aircraft of all-duralumin construction, or a combination of duralumin and steel, than on aircraft in which wood construction is used.

The airplane manufacturer, by using standardized parts, would realize a financial saving, both as to initial cost and the labor of checking the strength of each individual part.

One of the most important things that the Society's Standards Committee can do is to promulgate standardization at an early date, so that the manufacturers will not make tools which they may later have to discard because of subsequent standardization. Standards should be adopted, even though only tentatively, for everything possible. Conflict should be avoided, so far as it can be, between standards for commercial manufacturers and the military services.

The following subjects were suggested as items on which specifications might be developed: bell-cranks, clevises, tube-end fittings, push-pull controls, rubber grips for stick controls, door-locks, size and shape of corrugations in metal construction, and diameters and widths of brake-drums.

Mr. Naylor further recommended that the fuel and oil-pipe dimensions specified by the Army Air Corps be considered by the Aeronautic Division for adoption as S.A.E. Standard. Consideration should also be given to specifications for both the welded and the seamless types of streamline tubing.

The present Army and Navy standard on seamless streamline tubing should be adopted or modified to meet commercial requirements, and an additional set of sizes should be formulated to cover welded tubing.

Unquestionably, the adoption of standards, in Mr. Naylor's opinion, will result in a tremendous benefit to the aeronautic industry.

Airplane Lighting

Increasing demand of manufacturers of airplanes for lighting equipment to meet the conditions of night-flying and to provide satisfactory landing-lights for use on unlighted airports has presented a problem to the manufacturers of lighting equipment. The seriousness of the situation and some ideas as to the demands being made were outlined in a paper on Airplane Lighting Requirements prepared by L. E. Lighton, of the Electric Storage Battery Co., and W. M. Johnson, of the National Lamp Works of the General Electric Co.

It is hoped that a discussion of this subject will result in information which will be of assistance to a committee to be formed to consider the development of suitable lighting equipment.

From figures published by the Department of Commerce, it is estimated that about half of the regularly used airways are lighted for night-flying and that a very small percentage of the airports are equipped with lighting facilities for night-landing. This indicates necessity for providing airplanes with efficient lighting equipment.

In addition to high-intensity lighting needed for following unlighted routes and for landing in unlighted fields, airplanes require navigation lights and illumination for instruments and cabins. The entire problem of airplane lighting resolves itself into three divisions: illumination requirements, lighting equipment, and energy supply and distribution.

Landing-Light Requirements Difficult

Mr. Lighton pointed out that visibility with navigating lights at certain distances and through certain angles are already required by the Department of Commerce regulations. Cabin lighting must be sufficient for passenger convenience; for instruments only sufficient illumination to read the dials is required. Landing-light requirements present the most difficult of the problems because of the intensity and quantity of light required. Up to the present no tests have indicated the exact amount of light that is needed for following unlighted routes and for landing.

After investigation has demonstrated the quantity and distribution of light required, it will be necessary to design lamps giving low wind-resistance and so constructed as to minimize vibration. The question of energy loss in the wiring system must be adequately covered. Lighting equipment that can be inserted completely within the wing or made retractable into some part of the airplane will assist most in increasing the efficiency of the airplane.

The serious question is the method of providing sufficient energy during a given period of time from a battery alone or by a generator-battery system. Here the element of weight severely curtails at present the amount of energy that can be supplied. No definite data are available on socket voltages; some determination of this matter must be made before adequate systems can be designed.

It therefore seems advisable to start immediately investigations that will lead to standardization of lighting equipment, including its location and wiring. At the same time, definite practice should be established for battery and generator-system ratings and the sizes to be used for night-lighting purposes. This entire matter will be made the subject of study by a committee to be constituted of representatives of airplane and of lighting-equipment manufacturers.

In discussing the paper, Mr. Egtvedt, of the Boeing Airplane Co., said that his company uses a 25-watt generator on its 12-passenger airplanes, and that this seems to be ample. Illumination required for landing is considerably greater than that needed to light the cabin. However, the pilots usually turn on all the lights when required to land at night.

Mr. Egtvedt raised the question of large generator-capacity for use in connection with radio equipment, which may require a separate electric-current source. Some difficulty has been experienced from light reflected from propellers. It is Mr. Egtvedt's opinion that the landing-light should be pointed to throw the light outward on each side and downward. These matters will all be given consideration by the committee.

Proposed Aeronautic Specifications

Chairman Warner, after outlining the specifications adopted by the Society last June, mentioned the various items now under consideration by different subdivisions of the Aeronautic Division.

The question of a magneto flange-mounting, which has been submitted to manufacturers and users of the flange-mounting type of magneto, brought forth an opinion from A. J. Poole, of the Robert Bosch Magneto Co., that flange mountings in general for magnetos are somewhat hazardous, except in the case of vertically mounted equipment. Whereas the design submitted for consideration is a two-bolt type, he recommended that three or four bolts be used in horizontally mounted magnetos.

T. Z. Fagan, of the Scintilla Magneto Co., stated that there is need for a flange-mounting specification and that his company is building two types of such mounting, one identical with the design suggested for S.A.E. specification, and the other a three-bolt flange. The three-bolt flange is suitable for the heavier magnetos of from 9 to 15 lb. He expressed the hope that some suitable solution of this problem can be found within a short time. Considerable interest was expressed in the proposed work by others present, and it is probable that a subdivision of the Aeronautic Division will be appointed at once to consider the subject.

The report of the Subdivision on Tires, Wheels and Rims was presented merely as one of progress. It will be printed in the November issue of THE JOURNAL under Standardization Activities. It is anticipated that the Subdivision will make a definite recommendation on this subject to the Aeronautic Division at its meeting to be held in December.

A design of ball-type spark-plug terminal submitted for consideration elicited no discussion. However, this design has been submitted to engine and spark-plug manufacturers, and some criticisms and suggestions have been received, together with samples of the proposed and the existing types. Before any decision can be reached, further agreement must be reached through a committee of manufacturers and users.

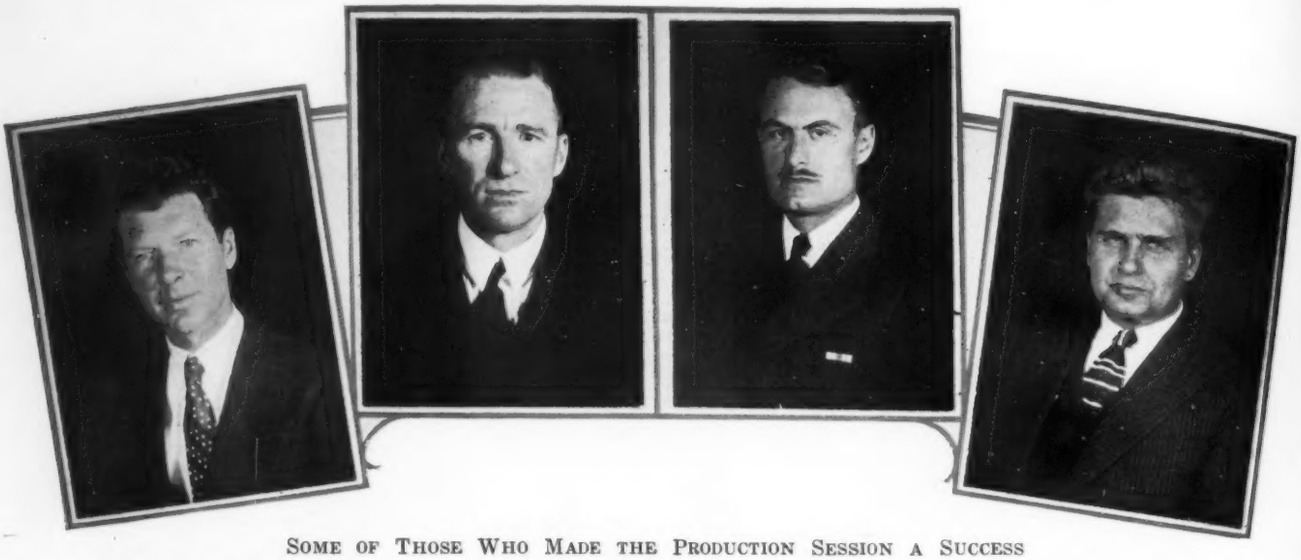
A proposed revision of the existing S.A.E. specification on tachometer drive was outlined. The present specification has been published in the S.A.E. HANDBOOK for a number of years but differs in some details from present practice. This specification is being revised in accordance with usage. The revision will be submitted to the Standards Committee for approval in January.

No detailed discussion was undertaken on a proposed additional propeller-hub and shaft-end of the splined type. The suggested size would augment the present three sizes and provide a splined shaft-end suitable for engines of less than 100 h.p.

Before final action is taken, details of all of the proposed specifications will be printed in THE JOURNAL under Standardization Activities.

SOME OF THE ACTIVE PARTICIPANTS IN THE AERONAUTIC STANDARDS SESSION

The Hon. Edward P. Warner, Assistant Secretary of the Navy for Aeronautics (Center), Chairman of the Session. (Upper Row, Left to Right) Secretary and General Manager Coker F. Clarkson, of the Society, Who Told About What the Aeronautical Industry Can Learn from Automobile Standardization; C. L. Egtvedt, General Manager of the Boeing Airplane Co., Who Took Part in the General Discussion; W. C. Naylor, Chief Engineer of the Stinson Aircraft Corp., Who Discussed Aeronautic Standards from an Airplane Manufacturer's Viewpoint. (Second Row, Left to Right) J. H. Kindelberger, Chief Engineer of the Douglas Aircraft Co.; A. J. Poole, of the Robert Bosch Magneto Co.; and J. J. Murray, President of the Aircraft Holding Co., Who Took Part in the Discussion on L. E. Leighton's Paper on Aircraft Lighting Requirements



SOME OF THOSE WHO MADE THE PRODUCTION SESSION A SUCCESS

(Left to Right) George H. Prudden, Managing Director of the Prudden Aircraft Corp., Who Presented a Paper on Metal Airplane Construction Economics; Commander E. M. Pace, Government Inspector at the Douglas Co. Plant, Who Discussed Lieut.-Commander L. B. Richardson's Paper on Maintenance of Duralumin for Naval Airplane Structures; and H. V. Thaden, Vice-President and General Manager of the Thaden Metal Aircraft Corp., Who Spoke on Metal Aircraft

Problems of Metal Construction

Corrosion of Aluminum Alloys the Greatest Difficulty—Determinate Materials, Indeterminate Forms Favored

COMMANDER E. E. WILSON, chief of staff to Commander of the Aircraft Squadron with the Battle Fleet, presided at the very interesting session held on the evening of Sept. 11. He said that the use of duralumin in aircraft construction is distinctly limited by the characteristics of that material. Working over the sea in the presence of salt water involves very lively corrosion of the metal, and the general problem in this connection is not solved. Duralumin construction is being proceeded with, however, careful study being made to limit the extent of corrosion. Land airplanes working from carriers are not subject to corrosion as are seaplanes.

Lieut.-Com. L. B. Richardson, of the Naval Air Station, San Diego, who addressed the members on the subject of maintenance of duralumin for Naval aircraft structure, has had long experience in overhaul and maintenance work with fleet aircraft. The Naval activities on the Pacific Coast consist of two parts embodying the operating units of the fleet and the Naval air-station at San Diego, the fleet air-base, at which the Naval aircraft are repaired. When aircraft or engines have served the required time and are in need of overhaul, they are returned to the air station for repair.

Commander Richardson showed clearly that strong alloys of aluminum are extremely susceptible to corrosion, not only on their surface but along the boundaries of their crystals. It seems to be characteristic of duralumin that it corrodes and disintegrates under a paint coat applied after cleaning the metal by ordinary means; the disintegration often not being apparent until blistered or discolored spots in the paint are scraped. Aluminum alloys in seaplanes present perhaps the most difficult maintenance problem encountered anywhere, except, possibly, in a salt-refining works. Duralumin members covered when new with excellent-appearing varnish-paint have shown numerous blisters ½ in. in diameter within less than three months after they were sent from reputable airplane factories. Plates removed from the bottom of year-old duralumin hulls are corroded badly at joints and areas of contact with wood, steel or other surfaces of duralumin. In such cases the surfaces were not properly prepared for painting and the joints were not made with sufficient packing and paint.

Wings suffer from two other causes of corrosion, brass and copper in contact with duralumin and lack of protection from the paint due to the action of dope.

SHOULD DESIGN TO AVOID CORROSION

Duralumin will corrode rapidly even in the presence of non-salt moisture. It is essential that the best available principles and practices be followed in the original protection and in field and shop maintenance of duralumin structures if they are to operate safely in the length of service that can be expected if duralumin is treated as intelligence and experience dictate. In Commander Richard's opinion, there is an indisputable field of usefulness for aluminum alloys in the primary structures of all classes of aircraft. It behooves the industry to develop designs which will utilize duralumin in shapes and assemblies that lend themselves most readily to protection and maintenance.

The all-duralumin airplane as now constructed in this Country is quite unsuitable for seaplane service. Salt water would lodge at the trailing edges of all surfaces and along the bottom seams and joints of the fuselage and wings, in spite of all the drain-holes that could be made. The only serviceable type of all-duralumin construction for seaplanes is believed to be that employing water-tight joints and seams throughout, even on the wings.

Seaplanes should be washed with fresh water after each day's operation, and dried with compressed air. Interiors of both seaplanes and landplanes should be open for drying and airing at all times when standing. Duralumin seaplanes of all-water-tight construction should be overhauled at intervals of not over 15 months. Seaplanes and amphibians of which the major assemblies are fabric-covered duralumin frames should be overhauled annually, or sooner if extensive incipient corrosion is found at any time after six months of service. All duralumin seaplanes of non-water-tight fuselage construction would be worth overhauling after a year's service.

Commander Richardson is of the opinion that, in their current work, engineers have, with few exceptions, been unduly optimistic as to the allowable bearing strengths of metals. Consequently, the principal highly strained connections of aircraft, such as wing hinges, strut connections, landing-gear and engine-mount attachments have too little bearing area for the bolts and pins.

Alclad aluminum-alloy, which consists of duralumin on which an exterior of thin aluminum of pure grade has been rolled in the ingot, is now available in cheap form. It will be available soon in tubing, alclad both inside and out. It is stated that the pure aluminum has the dual advantages of offering somewhat greater corrosion-resistance than duralumin and of protecting the duralumin from electrolytic action, the aluminum being attacked.

Commander Richardson emphasized very strongly that even though alclad be used, airplane structures must be designed, protected and maintained with all the care found necessary when utilizing ordinary duralumin. It has been demonstrated by C. W. Hall that aluminum alloy can be protected to a reasonable extent from salt-water corrosion-effect by a film of grease.

With regard to the use of aluminum in Naval aircraft, Commander Wilson said that this is necessary, owing to the design features that are demanded by the fact that the Navy has relatively very little space on aircraft carriers and must use planes of the smallest possible size. The U.S.S. Langley has a flying-deck about 500 ft. long. As many as 32 planes have been operated simultaneously from the flight-deck.

George H. Prudden, managing director of the Prudden Aircraft Corp., said that in eight years of operating duralumin landplanes severe conditions of corrosion have not been encountered, no rivets having fallen out. He said it is realized, however, that great care should be taken in the construction of the planes.

Favors "Indeterminate" Structure-Form

H. V. Thaden, vice-president of the Thaden Metal-Aircraft Corp., who presented a paper setting forth the developments in and his idea of metal construction, was of the opinion that designers in general believe that even-

Members Who Had Charge of Local Arrangements

Officers of the Southern California Section Who Cooperated with Ethelbert Favary in Handling Meeting Matters Locally: Treasurer, J. J. Canavan (Upper Left); Secretary F. C. Patton (Upper Center); Chairman Eustace B. Moore (Lower Left); and Vice-Chairman W. H. Fairbanks (Lower Center). Donald Hall (Upper Right), Designer of the Spirit of St. Louis, Was Also a Member of the Committee. Cliff Henderson (Lower Right), Managing Director of the National Air Races and the California Air Race Association

tually all aircraft will be of metal construction, whatever the particular metal may be. He said that control surfaces can be made at lower cost and are more satisfactory in metal than in fabric.

Mr. Thaden presented, as the most interesting feature of the construction of his company, the adherence to indeterminate forms of structure. This is based on the belief that aircraft in the hands of the public, as a whole, should be of foolproof structure. Something revolutionary in the way of aerodynamic theory that will make airplanes safer is anticipated. Mr. Thaden argued that in steamship, railroad and automobile practice there has been a gradual evolution from a determinate structure using indeterminate materials to indeterminate structure using determinate materials; as materials have improved, structures have become more complex. By "determinate material" Mr. Thaden means material having uniformity and dependability of physical characteristics such as those of metal as compared with an indeterminate material like wood or fabric.

The members will appreciate receiving at an early date from Mr. Thaden a detailed statement of the different points of his interesting construction.

Mr. Prudden, in his paper on Economies in Producing Metal Airplanes, gave valuable information based on long experience and practice. He said that the metal plane is the only answer in mass production, toward which all are looking. He related specifically the steps taken in heat-treating and fabricating duralumin and assembling parts made thereof.

Instruments and Research

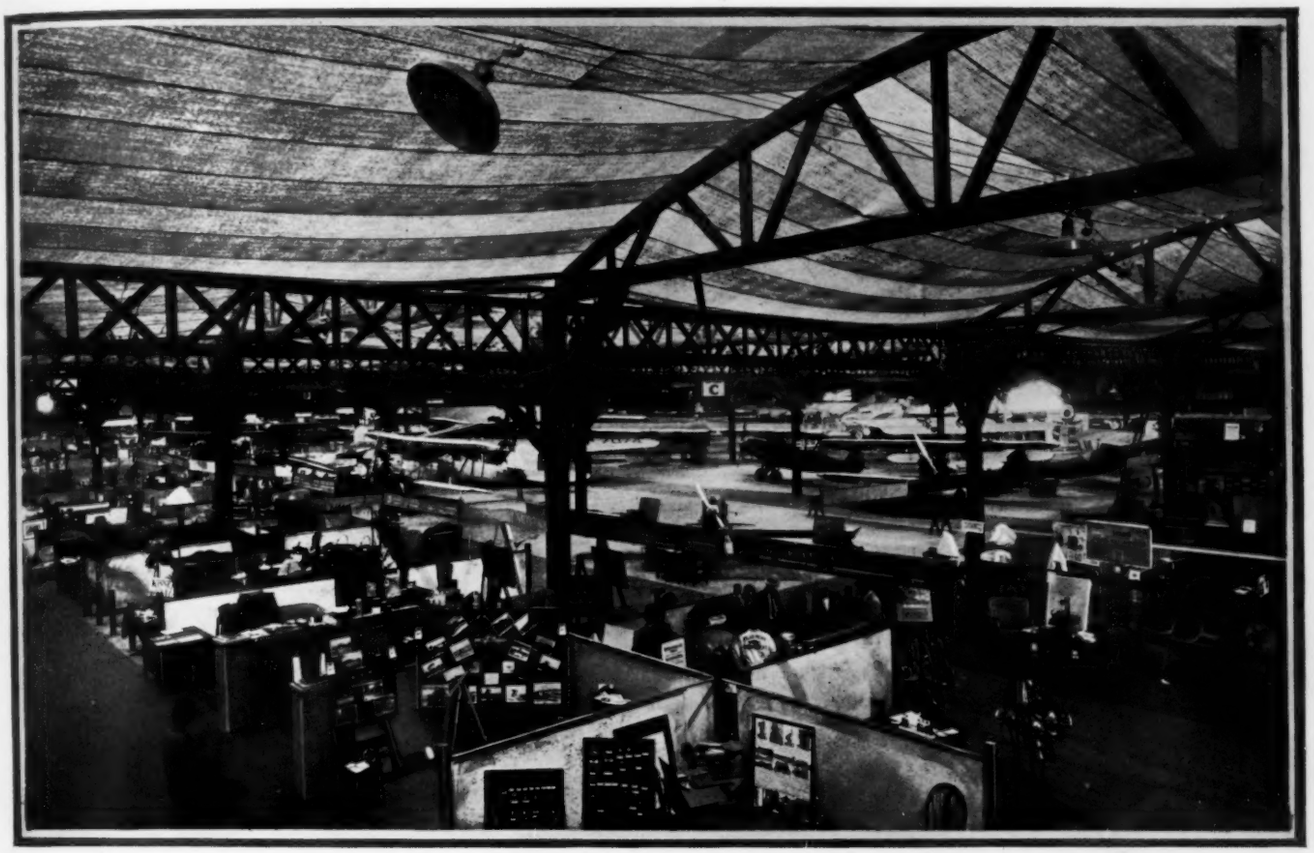
Ground Clearance and Wind Indicators Needed—New Wind-Tunnel and Stable Airplane Described

THE session held on the morning of Sept. 12, with L. M. Griffith in the chair, was devoted to airplane instruments, wind-tunnel construction and aerodynamics.

Speaking of the fact that instruments are being used more and more in flying, Mr. Griffith said that old pilots who have flown by visual observation of the ground are at a loss when they cannot see the ground; so they find it difficult to depend upon instruments. However, in flying at night or in thick weather in the daytime, with large aircraft particularly, dependence must be placed upon instrumental guidance

SPEAKERS AT THE INSTRUMENT SESSION

L. M. Griffith, of the Emsor Aero Engine Co., Who Presided as Chairman (Center). Lower Row, Left to Right, Dr. Clark B. Millikan, Who Described the Aeronautic Laboratory of the California Institute of Technology; Maurice Holland, of the National Research Council, Who Took Part in the Discussion; and W. P. Balderston, of the Pacific Scientific Co., Who Discussed the Latest Types of Instruments



INTERIOR VIEW OF THE AERONAUTIC EXPOSITION STAGED AT MINES FIELD, LOS ANGELES

rather than upon personal judgment. In large airplanes the visibility to the ground is not as good as in smaller airplanes.

W. P. Balderston, of the Pacific Scientific Co., talked of recent developments in instruments. He spoke of Colonel Lindbergh having come to him to talk about instruments before making his New York-to-Paris flight. Mr. Balderston did not at the time consider that flight practicable. It was the first time that anyone had considered such a long-distance flight of any kind without a navigator. Much has happened since that time. Colonel Lindbergh navigated in a way that many who were engaged in the aeronautic industry did not think possible, notwithstanding instruments had been developed sufficiently to accomplish the flight, which initiated the present unprecedented activity.

Mr. Balderston showed lantern slides illustrating various types of airplane instrument, and gave a short description and explanation of each.

SOME NEEDED INSTRUMENTS

Speaking of the further needs of navigation, he mentioned the demand for an instrument that will indicate height above ground regardless of elevation above sea level. Obviously, in blind flying the principal danger is that of flying into ground or against a hill or mountain. Proposed methods for determining height above ground involve the utilization of the reflection of sound waves, reflection of radio waves, and the capacity of an inductor.

A meter to indicate the rate of flow of fuel to engines has been developed. With it greater fuel economy can be secured.

In conclusion, Mr. Balderston said that there is great need for an instrument that will indicate direction and velocity of wind without taking sight of the ground or of the stars; and that a fortune is waiting anyone who can devise such an instrument.

Mr. Griffith observed that it is likely that ultimately the functions of several of the many instruments now made for the use of pilots will be combined so that there will be a smaller total number of instruments that need attention.

PROGRESS DEPENDS ON RESEARCH

In introducing Dr. Clark Millikan, of the California Institute of Technology, Chairman Griffith said that, in general, research work in aeronautics is far ahead of the practical application of the resulting data and information, and that, moreover, this state of affairs probably will always exist. There is necessarily a considerable gap between the product of the research laboratory and the type of information which the designing engineer can apply immediately in his problems.

It must be realized, however, that future progress depends upon research work. It is therefore essential that research be fostered. Research activity has been substantially augmented very recently by the Guggenheim Fund assisting various institutions to establish aeronautical laboratories. There are two such laboratories on the Pacific Coast, one at Stanford University and the other at the California Institute of Technology. The work of such laboratories is, on the one hand, to evaluate physical constants entering into performance of aircraft elements, with reference particularly to aerodynamic performance, and, on the other hand, to discover new laws or extend old laws to assist in the development of the art. For a number of years this Country lagged behind in worldwide aeronautical laboratory work. It is now, in Mr. Griffith's opinion, occupying a leading position in some phases of this work.

Dr. Millikan, research fellow of the Daniel Guggenheim Graduate School of Aeronautics, described the wind-tunnel now being constructed at the California Institute of Technology. He made a masterly address on the general subject of the necessity for wind-tunnel

research and the development of wind-tunnel construction since the time when Eiffel first saw the need for accurate data on forces of movement in air.

Some of Eiffel's flat plate-work is still accepted, this constituting the beginning of experimental aerodynamics. Later, tunnels of different types were constructed in Germany and Russia and then in other countries. Designers became embarrassed by the large amount of inconsistent non-systematic data. Coefficients were found to be not constant, their values changing in scaling-up and tunnels differing from one another in turbulence effect and in other respects. Now, tunnel tests can be conducted with some systematic organization as to outcome.

The California Institute of Technology has on its staff an unusually large number of well-trained mathematicians and physicists. It is seeking to conduct advance research with the purpose of connecting more effectively research data and practical investigation; and also to train research men for work in other institutions and organizations. Many laboratories are in great need of men of greater fundamental scientific training. The conduct of a normal engineering-school is also planned.

In this work it was thought necessary to have a large wind-tunnel as a central feature. This tunnel is now nearing completion. It is of the open-chamber type. The working cylinder is 10 ft. in diameter. The tunnel is of concrete construction and is equipped with a 500-hp. motor with overload capacity of 750 hp.

It is hoped that a complete description of this wind-tunnel can be published in THE JOURNAL at an early date.

STABLE AIRPLANE MODEL EXHIBITED

Dr. Millikan also exhibited and described a model of a type of airplane developed by Dr. A. A. Merrill, of the California Institute of Technology. A detailed description of this also, it is expected, will be published soon. This plane was exhibited and flown at Mines Field during the air races. It is the result of studies made by Dr. Merrill of staggered-decalage wing-combinations, with which it has been found there is no pitching effect; there being no longitudinal oscillations without the stabilizer behind.

Dr. Millikan said that the staggered decalage gives stability without the rear stabilizer, but does not alone give control. Dr. Merrill found that an elevator was not suitable and tried shifting the center of gravity by applying a lever to the pilot's seat. This, however, set up oscillations and was abandoned. Now, the fuselage is swung as a whole from the upper wing, the wing swinging relatively to the fuselage. The upper and lower wings are mounted rigidly together and pivoted on the upper wing. By rotating a nut, the pilot swings the lower wing forward or backward. The fuselage of the airplane is short because there is no need for a rear stabilizer. An elevator was installed; also a large rudder.

With this construction, it is stated that the pilot need have no worry whatever about longitudinal pitching. It is also said that the principle is applicable to airplanes of small size. In the case of large airplanes, utilization of the principle would, it seems, for structural reasons, be difficult but not insuperable.

Airplane and Engine Design

Molded-Plywood Fuselage Construction, Effect of Battle Tactics, and New Planes and Engines Described

E. E. ALDRIN presided at the Design Session held on the evening of Sept. 12. At this session G. F. Vultee, chief engineer of the Lockheed Aircraft Co., described the methods and materials employed in the fabrication of the Lockheed Vega model. The fuselage is of the plywood type. In the construction of this, a mold made of concrete is employed, the inside of this mold being made to conform to the outer contour of the fuselage. After the wood is fitted to the inside of this concrete form, a male member is pressed down. In this manner the exact forming of the fuselage is accomplished. A paper on this construction will be published in a future issue of THE JOURNAL.

W. D. Waterman, experimental engineer of the Bach Aircraft Co., took up the matter of the needs of air-transport equipment. He called attention to the fact that the industry has been producing three distinct classes of airplane: first, three-place open-cockpit type, such as the Waco, the Eaglerock and the Travel Air, powered with various types of engine ranging from the OX5 to the Wright Whirlwind; secondly, the five and six-place cabin-airplanes, such as the Ryan, the Fairchild, the Lockheed and the Stinson, powered in most cases with the Whirlwind; and thirdly, the larger tri-engined airplanes, such as the Ford and the Fokker, powered with Whirlwinds and Wasps.

PROFITABLE LOAD PERCENTAGE

The designers of the Bach Air Yacht endeavored to fill the gap between the second and the third classes by producing a light fast three-engined plane. A large flying unit undoubtedly is most economical for air transportation; however, at present this type of airplane carries in commercial service an average of only 40 to 50 per cent of its capacity. Mr. Waterman said that it is hopeless to endeavor to operate at prevailing rates a line of single-engined aircraft carrying but four or five passengers. An average of 85 per cent of total load-capacity must be maintained with such equipment. The larger tri-engined planes can be operated at 60 per cent capacity on a paying basis.

The Bach Aircraft Co. expects to have in operation within a year a 22-passenger airplane powered by four engines. The fuselage will be very deep vertically, with two passenger-decks. A feature of the design is two nose-engines, one directly above the other.

Commander Wilson gave a very valuable paper on the influence of battle tactics on design technique. This paper is printed in this issue of THE JOURNAL. The members are greatly indebted to Commander Wilson for his very informative official statement on the types of aircraft that the Navy has been using, the reasons therefor, and the new designs that will be put into service at an early date.

Lieut. L. P. Delsasso, associate in physics at the University of California at Los Angeles, told of an investigation that has been conducted at that institution with a view to determining the practicability of acoustic methods for determining distance, with the intention of creating a new type of altimeter. No altimeter based on the results of the investigation has been made. A description of the principles and methods employed will be published later.

DEVELOPMENTS IN ENGINE DESIGN

Arthur Nutt, chief engineer of the engine division of the Curtiss Aeroplane & Motor Co., Inc., in response to special request, talked on recent developments in airplane-engine design. He said that his company is producing a small air-cooled engine in which the number of parts is reduced as much as possible, particularly the moving parts. The theme is that the engine should be as simple as possible to maintain in the field; with no gears to adjust, no bevel-gears, every gear in the engine being of the spur type. There are no moving parts in the intake system of this engine.

The Curtiss Company is also making a 12-cylinder air-cooled engine having two banks of six radial cylinders, one bank directly behind the other. This engine is in type a combination

of the radial and the vee construction. The vee type is attractive from the viewpoint of low frontal area, but not from the standpoint of weight.

In connection with the long-continued controversy as to the relative merits of air-cooled and water-cooled engines, Mr. Nutt, who has always been a strong proponent of the latter type, without malice, called attention to the fact that three important world's records are now held by water-cooled-engined aircraft; namely, the high-speed record, the endurance record, and the long-distance record.

Mr. Nutt believes that any engine with as low weight-power ratio as 1½ lb. per hp. requires an oil-cooler. Most of the engines of 400 hp. are equipped with oil-coolers. He said that engines of rated power in excess of this should have oil-coolers to prevent excessive oil temperatures. In Europe all large air-cooled engines are so equipped.

The conditions in general with regard to cylinder wear, said Mr. Nutt, are as good in air-cooled engines as in water-cooled engines, provided the temperature of the air-cooled cylinders is not permitted to become excessive. Unless cylinders are properly cooled, there will be undue rate of wear on rings and cylinder-walls.

CHAIRMAN AND SPEAKERS AT THE AIRCRAFT DESIGN SESSION

(Top, Left to Right) Arthur Nutt, of the Curtiss Aeroplane & Motor Co., Who Described Recent Developments in Aircraft Engines; E. E. Aldrin, of the Standard Oil Co. of New Jersey, Chairman; Commander E. E. Wilson, Chief-of-Staff to Commander of the Aircraft Squadrons with the Battle Fleet, Who Gave a Paper on The Influence of Battle Tactics on Design Technique. (Lower Row, Left to Right) G. F. Vultee, Chief Engineer of the Lockheed Aircraft Co., Who Told of Methods and Materials Used in the Lockheed Vega Model; L. P. Delsasso, of the University of California, Who Analyzed the Principles of a New Type of Altimeter; and Waldo D. Waterman, Experimental Engineer of the Bach Aircraft Co., Who Spoke on Air Transportation Needs as Analyzed in Designing the Bach Air Yacht

Excellent Transportation Program Arranged

Attendance of Over 600 Expected at Newark Meeting—Metropolitan Section and Automotive Associations Cooperating

WITH relatively few exceptions, every member of the Society vitally interested in fleet operation and maintenance (and according to a recent check of the membership, there are over 450, or 7 per cent, of the Society members directly engaged in fleet operation and maintenance) will be found at S. A. E. headquarters at the Robert Treat hotel in Newark sometime during the three days of the Transportation Meeting, Oct. 17 to 19. In addition to those directly engaged in fleet operation and maintenance, members of the Society interested in hearing what operators have to say about the current designs of motor-trucks and motorcoaches will find it greatly to their advantage to attend the seven technical sessions.

Every member of the Society will be interested in the principal address at the Transportation Dinner. Dr. Miller McClintock is, without question, the foremost authority on traffic control, being director of the Erskine Bureau of Street Traffic Research at Harvard University. In accepting the invitation of the Transportation Meeting Committee to speak at the Transportation Dinner, he has assured the success of the dinner and has made it more than worthwhile for every member of the Society, no matter where his interests lie, to attend the Transportation Meeting.

Ten years ago a National Meeting of the Society devoted entirely to the operation and maintenance of heavy-duty motor-vehicles was undreamt of. The increased interest in automotive transportation has resulted in the holding of a yearly three-day National Meeting devoted to the discussion of the engineering problems involved, and bringing together representatives of practically every industry, for there are few industries that are not directly concerned with automotive transportation today.

In the first *Meetings Bulletin*, F. C. Horner, chairman of the Transportation Meeting Committee, stated that the meeting would bring together a professional group that is larger than almost any other in the Society except the motor-vehicle group and second to none in importance, for the motor-vehicle transportation industry has taken the position with respect to the design and manufacture of equipment that the railroad industry has taken with respect to the design and manufacture of railway equipment.

Although the meeting will be held in Newark, it is in Metropolitan Section territory and the Metropolitan Section is consequently taking an active part in the program. The Motor Truck Club of New Jersey is also cooperating, President Bacon and Secretary Way of the association being on the Transportation Meeting Committee. The Automobile Trade Association is also helping. Sizable delegations from the New England, the Pennsylvania and the Washington Section are also expected, the members of the New England and Pennsylvania Sections having had the opportunity in past years of attending Transportation Meetings held in their own cities. Transportation interests in the Society are especially prominent in the Eastern and Far-Western Sections. Several of these Sections consist almost entirely of members in the operation, maintenance and service work, this accounting for the increased interest in the Eastern Sections as compared to the Middle West.

Committee Reports

One of the important features of the Transportation Meeting will be the reports of the several subcommittees of the Operation and Maintenance Committee which has been very active during the past year under the chairmanship of R. E. Plimpton. These reports will be presented at an open session and, as the titles indicate, the reports are of vital interest to every operator. E. C. Wood of the West Coast Subcommittee has submitted the report of that subcommittee, which will be available in mimeographed form at the meeting. This report, which touches upon every phase of operation and maintenance on the West Coast, covers more than 100 pages. Any member who is familiar with automotive transportation on the West Coast can appreciate its value. As has been stated many times, the West Coast, with its long-distance operations, has been a proving ground for the entire industry and has developed practices which are worth careful study even though they cannot be applied *in toto* in Eastern operations.

Technical Program

The following is an attempt to state briefly the importance of the various papers and events.

Bus Transportation Session.—The Public Service Corporation is probably one of the largest operators of motor equipment in the Country, and this equipment is under the direct supervision of A. T. Warner. W. E. Travis of the California Transit Co. has just completed the first motorcoach transcontinental line. The Bus Transportation Session therefore brings together the leading exponents of short-haul and long-haul transportation.

Business of Transportation Session.—Applying the Motor-Vehicle to Business, by W. F. Banks, of the Motor Haulage Co.; and The Real Job of the Motor-Vehicle Fleet-Superintendent are titles that explain themselves.

Motor Haulage Session.—Two papers will be presented at the Motor Haulage Session: one devoted to ways and means of getting and holding business for the motor-truck and the other concerned with cooperation in the motor-truck operating field. This will be a joint session with the Motor Truck Club of New Jersey. Speakers for this session will be announced in the final *Meetings Bulletin*.

Six-Wheel Vehicle Session.—To what extent should legislation permit the use of the six-wheel vehicle? This is a subject of real interest to motor-truck operators and one that will be of even more interest in the future. The case of the six-wheel vehicle will be presented by Ethelbert Favary of the Moreland Motor Truck Co., which has had a great deal of experience in the design and operation of the six-wheel truck. The case for the public highway will be discussed by T. H. MacDonald, chief of the Bureau of Public Roads. Representatives of State Highway Commissions and others have been invited to sit in on the discussion.

Operation and Maintenance Committee Session.—At this session, reports will be submitted by Chairman Plimpton and the chairmen of the subcommittees as given in full in the program on the opposite page.

Store-Door Delivery Session.—The subject of store-door delivery is one which is becoming more important each year. No better authority than R.A.C. Henry of the Canadian National Railways could have been scheduled to speak on this subject. In the minds of the Transportation Committee, it is of sufficient importance to warrant an entire session. The discussion on Mr. Henry's paper should be of particular interest and should forecast the trend in store-door delivery in this Country.

Session on Three Service Problems.—In the final session, the East Coast will have an opportunity to learn from the representative of the West Coast, E. C. Wood, what has been accomplished in the West on three important service problems.

Holland Tunnel Trip

Through the courtesy of Ole Singstad, chief engineer, arrangements are being made for an inspection trip on Saturday morning of the Holland Tunnel and the ventilating plant, traffic control system and other features which have made the tunnel an engineering possibility.

Production Meeting Program

THE detailed program for the Production Meeting, to be held in Detroit, Nov. 22 and 23, has been announced by the Production Meeting Committee. Five technical sessions will be held, and on Thursday evening the production engineers and executives will be the guests of the Detroit Section at a Production Dinner. The papers which will be presented at the various sessions are as follows: How the Ford Motor Company Gets Its Phenomenally Low Production Costs —John Younger, Ohio State University; Production from the Accounting Point of View—L. A. Baron, Comptroller, Stutz Motor Car Co.; The Barnes Gear Shaver Process—H. D. Tanner, Pratt & Whitney Co.; Integral-Contact Gearing—A. B. Cox, Consulting Engineer; Honing Progress —C. G. Williams, Barnes Drill Co.; How to Decrease Production Costs 10 Per Cent—W. W. Nichols, D. P. Brown & Co.; and Development of Production Engineers and Executives—Paul Geyser, General Motors Truck Co.

Additional papers will be presented on material handling and time-study. There will also be luncheon conferences on selection and utilization of machine-tools and maintenance of plant equipment.

Reports of the several subcommittees of the Production Committee will be presented at the various sessions, these reports being as follows: Process and Equipment — Chairman G. W. Blackinton; Production Expense — Chairman H. P. Harrison; Time-Study —Chairman Eugene Bouton; Production Standards — Chiarman L. F. Maurer; Inspection Methods—Chairman Paul Abbott; and Material Handling—Chairman V. P. Rumely.

Transportation Meeting Program

Oct. 17 to 19, 1928 — The Robert Treat, Newark

Wednesday, Oct. 17

10 A. M.—BUS-TRANSPORTATION SESSION

Martin Schreiber, *Chairman*

(*Public Service Corp.*)

Short-Haul Transportation—A. T. Warner, Public Service Corp.

Long-Haul Transportation—W. E. Travis, California Transit Co.

2 P. M.—BUSINESS OF TRANSPORTATION SESSION

J. F. Winchester, *Chairman*

(*Standard Oil Co. of N. J.*)

Applying the Motor-Vehicle to Business—W. F. Banks, Motor Haulage Co., Inc.

The Real Job of the Motor-Vehicle Fleet-Superintendent—Donald Blanchard, *Operation and Maintenance.*

8 P. M.—MOTOR-HAULAGE SESSION

H. F. Bacon, *Chairman*

(*Gulf Refining Co.*)

Getting and Holding Business for the Motor-Truck

How Can Cooperation Help Truck Owners?

Thursday, Oct. 18

10 A. M.—SIX-WHEEL VEHICLE

Design versus Legislation Symposium

A. F. Masury, *Chairman*

(*International Motor Co.*)

Highway Legislation and the Six-Wheel Truck—E. Favary. Moreland Motor Truck Co.

Effect of Six-Wheel Vehicles on Highway Design—T. H. MacDonald, Chief, Bureau of Public Roads.

Prepared Discussion by Representatives of State Highway Commissions

2 P. M.—OPERATION AND MAINTENANCE COMMITTEE SESSION

R. E. Plimpton, *Chairman*

(*Bus Transportation*)

Report by Chairman Plimpton, of the Operation and Maintenance Committee

Report on Motor-Vehicle Data-Sheets—J. F. Winchester

Report on Effect on Maintenance of Accessories Such as Air-Cleaners, Oil-Filters and Shock-Absorbers—E. C. Wood

Report on Selecting and Training of Mechanics and Their Payment—T. L. Preble

Report on Administrative Systems and Methods—L. V. Newton

Report on Drivers, Their Training, Selection and Payment; and Operating Safety Measures—E. Favary

Report on Man Power Required per Vehicle Operated and Seasonal Fluctuations—F. C. Horner

6:30 P. M.—TRANSPORTATION BANQUET

Address on Traffic Control, by Dr. Miller McClintock, Erskine Bureau of Street Traffic Research

Friday, Oct. 19

10 A. M.—STORE-DOOR-DELIVERY SESSION

F. C. Horner, *Chairman*

(*General Motors Corp.*)

Canadian Store-Door Delivery of Today—R. A. C. Henry, Canadian National Railways

Prepared Discussion by merchants and by representatives of the railroads

2 P. M.—SESSION ON THREE SERVICE PROBLEMS

F. K. Glynn, *Chairman*

(*American Telephone & Telegraph Co.*)

Education and Prevention of Accidents—Is It Cheaper to Farm Out Work or Maintain Your Own Repair Shop?—When Is the Proper Time to Trade in the Old Truck?—E. C. Wood, Pacific Gas & Electric Co.

Saturday, Oct. 20

INSPECTION TRIP

Inspection of the plant and the traffic control in the Holland Tunnel

The Engineer and His Opportunity[1]

By C. F. KETTERING[2]

FOR a great many years industry was developed around products which had been conceived by the inventor, who, in the average business-man's opinion, was a type of human being to be confined to a corner where he would be beyond the reach of the public. Some of us, however, have always felt that engineering was an important phase of industry and that it should be classed as the equal and parallel of finance, sales and production. Yet only within the last 10 years has the engineer received this recognition, and perhaps nowhere could he have found such opportunity as has been presented by the automotive industry.

In a recent periodical it is related that only 30 per cent of the world's population has contributed to the development of machinery and machine-tools; therefore, 70 per cent of the 2,000,000,000 people in the world have done nothing toward facilitating human endeavor. The net result is that the engineering of today is so pre-eminent in the development of industry that it is not only a credit to the engineer but it is an honor to be associated with that profession. The engineer, in the modern interpretation of the word, has tried to evaluate, to predict and to complete ideas which have facilitated our normal human energies, so that the individual today has many fold greater ability to do things than he could possibly have accomplished at any time in the past.

C. F. KETTERING

If we read industrial history, we shall find there has always been the bugaboo that, if we continue to produce large quantities of any product, we shall ruin the market for it. Every year we hear and read that the last great year in the automotive industry has arrived. The following year, however, we sigh with relief when we find that, for some reason, the public is still buying automobiles. Records of the last few months show that production is greater this year than ever before. The American public is beginning to appreciate just what the automotive industry has accomplished. The industry is now a real competitor for supremacy in fast transportation. It has supplied the individual with a freedom of movement hitherto quite beyond conception, through the medium of everything brought about with the internal-combustion engine, including the automobile, the airplane, the motorboat, the truck and the tractor.

At one time the transmission of power from some central source was looked upon as the epitome of engineering endeavor, so far as transportation was concerned, since, as an example, it made possible the development of the street-car industry. It seems more significant, however, that automotive engineers visualized and developed individual transportation by means of vehicles equipped with localized powerplants.

Further elimination of distance has been brought about by the development of an international telephone and radio system, making it possible to have conversation with our friends on the other side of the Atlantic. All this has been the work of carefully planned, carefully studied details.

Surveying the industrial situation, we observe that a great many ideas, at one time considered impossible, are now realized. For the last 15 years engineers have been increasing piston speed in automobile engines. The point has now been reached where the average speed approximates 2500 ft. per min. Also, engine speed has been increased 1000 r.p.m. within the last three years. Average engine speed at present is ap-

[1] From an address delivered at the Detroit Section meeting, May 7, 1928.

[2] M.S.A.E.—General director, research laboratories, and vice-president, General Motors Corp., Detroit.

proximately 3000 r.p.m., and an engine capable of only 1000 r.p.m. could not be sold.

The public of today expresses its desires in no uncertain terms, not by issuing edicts, but by refusing to buy the product. Engineers have to realize that the public compels industry to act, at times, contrary to its own will. It is found, in such cases, that where this job is well done, all organizations associated with the movement have progressed. If the public desires anything and is willing to pay for it, engineers can usually accomplish that result. Companies in weakened financial condition have often shown a burst of engineering speed which has, ultimately, resulted in substituting dividends for debts. The point we need to emphasize, as engineers, is that, if engineering application can do this to a company that is in bad shape, how much more of an impulse it would give to the company if this application were made before it is absolutely necessary.

Instead of leaning on our laurels and looking for some resting place along the highway of progress, it is necessary that we continue our search for new things. This constant change is enforced upon the engineer. When a man reaches the age of 35 or 36 years and begins to be an important factor in any industry, three-quarters of the people in the world are younger than he is and they are telling him what to do. Today it is the younger generation that is telling father and mother what kind of an automobile they should buy. The car is not purchased on any deliberate sound, economic judgment, but on impulse of style and of performance. We have to study the younger generation and discover what it wants, recognizing that the younger people are operating the cars today and that the older opinion, conservative in business as it may be, is the balance-wheel.

We are dealing with such an important, impelling influence that we cannot quite comprehend it. Today we are talking about super-highways which are going to change completely our conception of transportation. There is no reason why we should not have express highways for automobiles, on which we can maintain speed in excess of 60 m.p.h.

An observation by Dr. Alexis Correll, of the Rockefeller Foundation, which should interest engineers, is that the one thing this world lacks more than anything else is imagination. Everyone can see a thing after it is produced but few can visualize it before it has been produced.

Step by step the embryo of yesterday is worked into the apparent perfection of today. If we do not look backward to see how much better we are than we were yesterday, but try to look forward to see how much worse we are than we can be tomorrow, a vista of accomplishment can be opened of which we never tire. There is no limit to the development and improvement of any of the things we know now, since we know so little. We know practically nothing of the great forces of nature. We have been using approximately 5 per cent of the power of our gasoline, but we can expect, as we learn more about combustion, to produce 1 hp-hr. per ¼ lb. of fuel. We are on the eve of the greatest development of power production, using the internal-combustion engine. We do not need to hesitate and think that the end has been reached, provided we have sufficient imagination to look back on what has been done and then attempt to gaze into the future. The opportunities and possibilities of the future are quite as great as they have been in the past, but they present different problems from the ones we have had in the past.

Metallurgically, again, we know but little today. New materials are coming to light constantly. We are associated with an industry which is to be different tomorrow, and therefore we should spend a little of our time in getting a better perspective of what we are about to do. Tomorrow, the next year, and the next 10 years are going to show as vast developments as the last 10 years have shown.

The difficulty with many engineers is that they find it comparatively easy to start from any place except where they are. If we are to go any place, we have to start from here. It is very difficult at times and it is only by persistent measuring, by persistent study, and by persistent looking ahead that we can tell which fork of the road to take. There is no profession with which I would rather be connected than that of the engineer. It is a new profession and a growing one. Engineers are being considered much more seriously in industry today and they are being taken into the confidences of the executives. All in all, the future of the engineer is full of promise.

The First Great Research Project

IF we may believe Pliny, Alexander the Great instructed his hunters, gamekeepers, gardners and fishermen to furnish Aristotle with all the zoological and botanical material he might desire; other ancient writers tell us that at one time he had at his disposal a thousand men scattered throughout Greece and Asia, collecting for him specimens of the fauna and flora of every land. With this wealth of material he was enabled to establish the first great zoological garden that the world had seen. We can hardly exaggerate the influence of this collection upon his science and his philosophy.

Where did Aristotle derive the funds to finance these undertakings? He was himself, by this time, a man of spacious income; and he had married into the fortune of one of the most powerful public men in Greece. Athenæus, no doubt with some exaggeration, relates that Alexander gave Aristotle, for physical and biological equipment and research, the sum of 800 talents (in modern purchasing power, some $4,000,000).

It was at Aristotle's suggestion, some think, that Alexander sent a costly expedition to explore the sources of the Nile and discover the causes of its periodical overflow. Such works as the digest of 158 political constitutions, drawn up for Aristotle, indicate a considerable corps of aides and secretaries. In short, we have here the first example in European history of the large-scale financing of science by public wealth. What knowledge would we not win if modern states were to support research on a proportionately lavish scale!—Will Durant in The Story of Philosophy.

Chronicle and Comment

Rules for Wright Brothers Medal Award

RULES governing the awarding of the Wright Brothers Medal as an insignia of honor for papers of merit on aerodynamic and related subjects have been issued in brochure form. Besides the rules, this brochure includes a brief history of the medal and a partial list of papers already published by the Society dealing with topics within the field for which the medal is to be awarded.

The idea of awarding such a medal was originated by the Dayton Section in 1924. The double purpose was to honor the Wright brothers and encourage the presentation, at meetings of the Society and its Sections, of engineering papers dealing with new developments in aeronautics. Subsequently the Dayton Section requested the Council of the Society to undertake the awarding of the medal, and, in compliance therewith, the Council appointed a Board of Award for 1928 consisting of Howard E. Coffin, chairman; Dr. George W. Lewis, and the Hon. Edward P. Warner.

The first award under the new rules is to be made for the year 1928. Copies of the rules are available at the office of the Society to all who contemplate submitting papers in competition for the award of the medal.

Reorganization by Divisions

THE proposal to change the executive and legislative organization of the Society so as to define more clearly the different divisions and give them proper representation, as described on p. 410 in this issue of THE JOURNAL, will be no surprise to most of the members, as there has been considerable agitation along this line for several years.

The Reorganization Committee which is working on this, with F. E. Moskovics as Chairman, deserves the hearty support of the membership, as its members are spending considerable thought and time on this subject, feeling that the future of the Society depends largely upon the decision that is finally made.

Several reasons exist for reorganization. Most important has been the feeling that, because of the rapid growth of some of the fields of interest of the Society, these have not had the representation on the Council to which they are entitled. This applies principally to the Operation and Maintenance, Production, Body Design, and Aviation interests. It is also felt that it is a defect of the present organization of the Society that our second Vice-Presidents have no specific duties.

This subject presents so many and such varied angles that the working out of the best plan is likely to require considerable time and study.

One of the first questions to arise was on what basis to make the fundamental classification of the Divisions. Another main question has been, How can each Division best expresses its wishes concerning who shall represent it in the Council and on the various committees?

So far, no decision has been reached, although certain fundamental ideas have been laid down by the Reorganization Committee as a basis on which to work. Whatever plan the Committee agrees upon will be submitted to the membership at the next Annual Meeting.

While it is desired that every Division shall be represented by its own chosen representative, care must be taken not to split the Society into groups, as it is believed that entire independence of the different Divisions would be one of the worst eventualities that could happen to the Society. This can be averted to a great extent by selecting to head each Division a man who is interested also in other Divisions of the Society.

It is natural for each of us to champion the branch of the industry in which he is directly interested, but we must be careful not to let our partisanship for any subdivision influence our judgment in doing whatever is best for the Society as a whole.—William Guy Wall, President.

An Aeronautic Advisory Board

SO rapid has been the progress in aviation of late that the Council has decided to take additional steps to keep the Society abreast of the developments, and, as a means to this end, President Wall has asked the members named below to serve on a special Aeronautic Advisory Board. The work of this Board will be to determine what the Society can best do to meet, through increased activities, the engineering and technical requirements of the areonautic engineers and the industry.

This decision of the Council is evidence of the great importance it attaches to aviation and aeronautics. More than 200 technical papers have been presented by leading authorities at Aeronautic Meetings of the Society since the inception of the industry, and during the last 12 months 240 pp., or 15 per cent of the text, in THE JOURNAL have been devoted to aeronautic engineering. Much standardization work has also been done in this field by the Society, during the activities of the World War and through the quiescent post-war period. At the Summer Meeting last June more than a dozen additional aeronautic standards were approved for adoption.

The increasing demand for interchange of aeronautic technical information, however, and for the establishing of engineering standards essential for the constructing of aircraft on a quality and an economical basis, has led to the decision to organize an Advisory Board to study the whole general situation. Following are the names of those who have been asked to serve on it:

Porter H. Adams
Capt. E. E. Aldrin
Howard E. Coffin
H. M. Crane
Hon. F. Trubee Davidson
Sherman M. Fairchild
L. D. Gardner
Brigadier-Gen. W. E. Gillmore
E. S. Gorrell
L. M. Griffith
Harry Guggenheim
C. M. Keys
Hon. W. P. MacCracken
Glenn L. Martin
W. C. Naylor
L. D. Seymour
William B. Stout
Ralph H. Upson
Hon. Edward P. Warner
L. M. Woolson

Naval Air-Tactics and Aircraft Design

By COMMANDER E. E. WILSON,[1] U. S. N.

WESTERN AERONAUTIC MEETING PAPER — *Illustrated with* PHOTOGRAPHS

THREE basic ways in which naval aviation can assist the battle fleet to attain victory are stated, and the aircraft are classified as fighting, observation, torpedo and bombing, and patrol planes. The primary and secondary uses of the types are set forth, and, since their tactical employment controls the features of their design, a brief sketch is given of the tactical considerations of fleet air-work.

The development of naval aircraft to date and the trend of future development are then described. As naval fighting planes must be carried on the ships of the fleet and must have the utmost possible performance and service ceiling compatible with low landing-speed, their size and weight have been reduced by the use of air-cooled radial engines and the intelligent employment of light alloys and ingenious detailed construction. The latest development in this class is a single-seater designed around the Wasp 500-hp. engine and equipped with a supercharger. It is light but is designed to carry a considerable load of bombs.

In the two-seater class the Corsair has been developed around the Wasp engine as a general-purpose machine. As a landplane it was adopted for airplane-carrier use in scouting squadrons. Now it is made readily convertible for use as a seaplane by the installation of a float, and as an amphibian by the attachment of retractible landing-wheels.

Through their use for a multiplicity of purposes, the former torpedo and bombing planes grew too large and a complete right-about-face was necessary. The problem was solved by the development of the Hornet and Cyclone 525-hp. air-cooled engines and the use of light alloys. The present Martin bomber is lighter by more than a ton than its immediate predecessor, has greatly improved performance and has flying qualities approaching those of the lighter craft.

Patrol planes also have gone through an evolution and now have metal hulls and wings and are built around the Cyclone and Hornet engines. They have recently established a large number of seaplane records. It seems desirable now to begin to redesign the airplane structure, with the purpose of making the patrol airplane as small as possible consistent with seaworthiness, long range, habitability for the crew, and offensive characteristics.

THE mission of naval aviation is to assist the fleet in attaining victory. The three basic ways in which this can be accomplished are: first, the direct offensive, or attack; second, the service of information, or scouting; third, the control of vessels' gunfire, or spotting. These three functions control the design of fleet aircraft.

Individual aircraft perform more than one function, but in general, to accomplish these objects, fleet airplanes fall into four classes: (*a*) fighting planes, (*b*) observation planes, (*c*) torpedo and bombing planes, and (*d*) patrol planes. Economy and facility of operation require that the number of types be reduced to the absolute minimum.

Fighting and torpedo-bombing planes are intended primarily for attack, observation planes are used for scouting and spotting, and patrol planes are also used for scouting, but primarily for that branch of scouting which includes long-range search. While these are the general employments of the different types, they may all be used on secondary missions, and the manner in which they are employed covers the whole broad field of naval tactics. Since the tactical employment of the aircraft controls the features of design, it is necessary to sketch briefly some of the tactical considerations of fleet air-work.

The time-honored axiom that the best defense is the strong offense is a controlling feature of strategy and tactics. We are accustomed to define strategy as the dispositions made prior to contact with an enemy, and tactics as the dispositions made and steps taken after contact. If a nation's strategic position is one of isolation, involving separation from any possible enemies by a wide expanse of water, the situation is at once of great assistance in defense and a great complication in offense.

Thus, if a nation desires to avoid fighting a war on its own territory, it must advance a great distance over sea and occupy the territory of its enemy. A campaign of this sort would be an enormous undertaking, involving much time and a large amount of money. It would necessitate a fleet seizing and occupying a number of advance bases and maintaining lines of communication to these bases. It would necessitate embarking a large number of troops and convoying them to the destination. It would then involve landing these troops, perhaps in the face of strong opposition, and of maintaining them as long as they occupied enemy territory.

The last war, insofar as we were concerned, involved much of this. We are all familiar with the escort and convoy system of that time. The control of the seas maintained by the Allied fleet during the war made possible the flow of personnel and materiel to the battle area. The enemy submarine attacks were a threat against the command of the sea, but when this threat failed the outcome was inevitable. History has demonstrated time and again that ultimate victory goes to that nation which controls the sea.

Since the present limitations of aircraft preclude their carrying the offensive to an enemy, it becomes necessary that fleet aircraft be embarked on the vessels of the fleet. At present it is impossible for any military or naval airplane to fly to the coast of a distant

[1] S.M.S.A.E.—Chief-of-staff to commander, Aircraft Squadrons, Battle Fleet, San Diego, Cal.

FIG. 1—LATEST NAVY FIGHTING AIRPLANE

This Is a Single-Seat Boeing F4B Built around the Pratt & Whitney Wasp 500-Hp. Engine and Is Designed To Carry a Considerable Load of Bombs and To Operate from an Airplane Carrier. The Powerplant Weight, the Structural Weight, and the Useful Load Are Almost Equal

overseas enemy, drop its destructive missiles, and return to its home base. With its fleet, however, a nation can advance its bases step by step and carry on the offensive. Therefore, the first requisite of fleet aircraft is that they operate from the decks of the vessels of the fleet.

The last preceding statement applies to all save patrol-type aircraft. At present these are large flying-boats, too heavy to operate from the decks of vessels. As an alternative, they are built to be seaworthy and airworthy, so that they can take passage with the fleet, using tenders in the fleet as their bases. These aircraft will operate normally from sheltered harbors, patrolling the seas against enemy submarines, surface vessels and aircraft, reporting what they see, and attacking with bombs when directed to do so.

It is necessary that these coastal patrol planes be naval planes, because they will be called upon to operate either with the fleet or with the merchant vessels of the Nation, in convoy, escort and submarine defense. During the last war the latter was the most important function that American naval-aviation performed. Those who sailed overseas will remember the large flying-boats and lighter-than-air ships which met convoys at sea and escorted them to their destinations.

Since patrol involves cooperation with and action against surface and subsurface vessels, the principles of unity of command demand that patrol planes be operated by the Navy. Even though they may be based in coastal harbors, they are naval aircraft. The organization to which they belong is rightfully determined, not by the shore base from which they take off, but by the sea objective which they attack. There are a number of patrol squadrons of this type, some of them based on shore and some based on fleet tenders.

Vessels of the battle fleet which bases in the waters of Southern California carry fighting, observation, and torpedo-bombing planes. These are transported on the three aircraft-carriers, the Lexington, the Saratoga and the Langley; on all the battleships of the fleet, and on all light cruisers. The Aircraft Squadrons, Battle Fleet, under the command of Rear Admiral Joseph M. Reeves, comprise 15 squadrons, a total of 206 aircraft. There are five fighting squadrons, of which two are carried on the Saratoga, two on the Lexington, and one on the Langley; four scouting squadrons, of which one unit is carried on the Langley, and one each on the Lexington and the Saratoga; two torpedo-bombing squadrons, one each for the Lexington and the Saratoga; three spotting squadrons, one for each of the three battleship divisions; and one patrol squadron, based on the Aroostook. This last-mentioned squadron accompanies the fleet under its own power but does not embark on board the ships. This command is equipped with aircraft which have embodied in them, as a result of years of intensive development, those factors which are peculiarly necessary to fleet aircraft.

AIR TACTICS IN A CAMPAIGN

In any overseas war, a campaign might consist of two phases. The first would involve advancing the bases and preparing the way for the actual offensive. This would be the strategic phase of the campaign. In the second phase, the actual battles would be fought. This would be the tactical phase. To appreciate the factors involved in naval aeronautic design, we must visualize briefly this latter phase.

Assume that one fleet, bent on landing the troops in its convoy, has entered the final theater of war, and assume that a second fleet, desiring to prevent the first from carrying out its purpose, has interposed itself between the first fleet and its destination. Each fleet is aware of the general position of the other and is anxious to close and fight it out. The commander-in-chief of each fleet will immediately endeavor to locate the exact position of the enemy and determine his disposition, so that he can best array his command to carry out the plan of battle. Each commander-in-chief, in addition to using surface scouts, will launch scouting planes to obtain this information, and will endeavor to prevent enemy airplanes from obtaining information. The scouting planes must, therefore, be capable of penetrating enemy screens, ascertaining the information desired, and transmitting this by radio at the earliest opportunity to their commander-in-chief.

Since radio is required, scouts should be two-seaters. Unless the battleships' decks are fitted for landing aboard, the battleship two-seaters must be seaplanes, and the battleships must be fitted with catapaults or cranes so that they can be launched. To return aboard, the planes must land alongside in the water and be hoisted in. If the sea is rough, this is impracticable. This hoisting-in process requires that the battleship be stopped, and no commander-in-chief will ordinarily care to do this. He must, however, scout in all weather. Battleship planes will, therefore, not ordinarily be used

for scouting, but for spotting the vessels' gunfire.

The two-seaters on the airplane-carriers, however, are available for scouting, since they can take off and land on the decks of the carriers regardless of the state of the sea and while the carriers are moving, and their operation does not restrict the movements of the fleet. Scouts are therefore carrier two-seaters. They will take off and scout according to a plan designed to cover all of the area possible in the probable position of the enemy. By means of radio they will report their position and the contacts they make. They carry guns to protect themselves against enemy attack. Since their mission is to obtain information, they will not be drawn aside by local combat, but will push on through in an effort to determine where the enemy is and how his vessels are disposed. They must get this back to the commander-in-chief by coded dispatch. When their mission is completed, they must return aboard. This scouting must be done continuously as the two fleets close, so that the commander-in-chief may know exactly what the enemy is doing, and act accordingly.

FIG. 3—THE CORSAIR EQUIPPED WITH FLOAT AND RETRACTIBLE LANDING-WHEELS

As an Amphibian This Craft Becomes the General-Purpose Airplane of the Battle Fleet. It can Be Flown as a Straight Landplane or, After Installation of the Float, as a Straight Seaplane. By Attaching Wheels to the Float It Can Be Converted Quickly into an Amphibian and, as Such, Loses Little of Its Performance in Flying-Qualities

HIGH-PERFORMANCE AMPHIBIOUS PLANES NEEDED

In the interests of economy and of facility of maintenance and operation afloat, the spotters and the scouts may be the same type of airplane. Since one is flown as a seaplane from the battleships and the other as a landplane from the carriers, they must be readily convertible from landplanes to seaplanes, and capable of being catapulted as either. They must be able to land more slowly than is necessary on shore, so that they can work in rough seas or land easily on the restricted decks of the carriers. At the same time, they must be capable of better performance than any possible enemy aircraft. Manifestly, conditions may arise in which the carrier planes may be obliged to land in the water, and the battleship spotters may find it very necessary to come aboard the carriers. An amphibian will be the ideal solution for this, if such an airplane could be built that would have very high performance.

The commander-in-chief of each fleet, having obtained information about the enemy, will immediately endeavor to attack, having as his first objective the enemy carriers. If he can sink these he will put out the eyes of the enemy fleet and draw a lot of the enemy's sting by depriving him of his air offensive. The commander-in-chief will, therefore, immediately drive home an attack. For this purpose he has at least two weapons; his heavy bombers and his fighting planes equipped with light bombs. If the range permits, he will no doubt send off his bombers, escorted by fighters. The fighters will endeavor to drive off enemy defensive planes and penetrate the enemy screen to the point where they can attack with light bombs. The bombers will then try to get in and attack from altitude. Torpedo planes may drop torpedoes, if this weapon appears desirable by virtue of the tactical situation as influenced by weather and other conditions.

FIG. 2—VOUGHT CORSAIR SCOUT AND BATTLESHIP SPOTTER

Adopted for Airplane-Carrier Use in Scouting Squadrons, It Was Designed Around the Wasp Engine and Has a Performance Approximately Equal to That of Contemporary Single-Seaters. It Is Compact Enough To Operate from Ships' Decks and Light Enough To Be Launched from the Catapults Now Afloat

The fighters which the commander-in-chief will use are single-seaters of very high performance. Having a normal armament of machine-guns, they must have the maximum performance pos-

sible in craft of their type. They must obtain this performance without sacrificing low landing-speed, since this is very necessary to carrier operation. They must carry a secondary armament of bombs, and as heavy a load of these as is possible. They are landplanes, operating from the decks of the carriers. They are equipped with some form of emergency flotation to keep them afloat for a reasonable period in case of forced landing at sea. They must carry the arresting gear necessary for landing on the carriers. In spite of these requirements, which are not imposed on shore-based single-seat fighters, they must be able to outperform any aircraft they may encounter.

Torpedo-Bombers and Their Offensive

The torpedo-bombers for this offensive work must also be carrier-based landplanes equipped with arresting gear and emergency flotation-gear. They must get off in the short run of the carrier deck burdened with the 2000-lb. torpedo or a bomb load of corresponding weight. They must have machine-gun protection, must be equipped with radio for communication, and must be capable of navigating a considerable range. With all this, they must be small enough to be carried and handled on the carriers' decks. They must have speed and maneuverability. They must be light, handy airplanes if they are to be flown on and off the decks.

The commanders-in-chief, in addition to taking the offensive against an enemy carrier and protecting his own fleet against an enemy offensive, will attack the enemy battle line, which, by a process of attrition, he will hope to wear down before the main engagement, thus increasing his chances of success. For this purpose the attack will be coordinated with that made on the enemy carrier. The battleships will have anti-aircraft protection in the form of guns and machine-guns of intermediate caliber. The developments to date in controlling these anti-aircraft batteries have been so rapid as greatly to endanger bombers approaching from altitude or torpedo planes approaching close to the water. These guns are no longer scorned by pilots. There are, however, means of combating them. The bombers may take advantage of cloud concealment. The torpedo planes may be accompanied by smoke layers, which may lay a curtain through which the torpedo planes can suddenly attack. The fighting planes, equipped with light bombs, may dive from the sun or cloud concealment into the enemy battleship, raining a storm of machine-gun bullets and small bombs into the anti-aircraft batteries, with the idea of making them untenable. This attack, coordinated with the torpedo and bombing attack, may give the bombing and torpedo planes a better chance of getting home. Even though the torpedo or bombing attack may not be successful in sinking a vessel, if it disables one or two of them to the extent of reducing the speed of the enemy fleet, a distinct advantage will be had.

The commander-in-chief of each fleet, during these preliminary engagements, will endeavor to maneuver his vessels in such a way as to bring his guns to bear to best advantage, drive home a submarine-torpedo or destroyer-torpedo attack in further process of attrition, and carry on the battle. As gun range is reached, the spotting planes get to work. Launched from their battleships, they take the air and assume a position designed to assist best in controlling their gunfire. At the time each commander-in-chief is endeavoring to control his own gunfire by aircraft, he will endeavor to deny this privilege to the enemy. To this end, he will take the offensive with combat planes from his carriers. His reserve spotters may form in a defensive group arranged for the best utilization of their machine-gun protection. The primary spotters will transmit to their vessels by means of radio the corrections for the fall of shot from these ships and other information of importance.

It is necessary to realize just how important this control of gunfire becomes. Prior to the advent of aircraft, an officer located in the highest possible position on the battleships' masts observed through a telescope the splashes of the salvos from the vessels' guns, and, estimating by eye the changes necessary, applied these changes to the guns to send the shots home. This process could be carried out to certain limited ranges, and in the design of battleships at that time it was considered unnecessary to elevate the guns higher than was necessary to give these limited ranges. The advent of the spotting plane advanced this range well beyond the limits of vision from the top. The commander-in-chief who can begin hitting beyond the range of any possible enemy hits and who, through superior speed and tactics, can maintain this hitting range has an obvious advantage.

Gunfire the Strongest Means of Offense

It is well to consider at this point that our own battle line consists of approximately 200 guns. These guns fire projectiles weighing from half a ton to a ton, depending upon their caliber, and loaded with bursting charges. Fired at long ranges, these shells fall at steep angles, approximately the angles of bomb-drops; in other words, they attack horizontal targets. Against this form of attack the heavy side-armor is, of course, useless. Since the guns can be fired at the rate of three per minute, our battle line can rain about 600 shell-bombs per minute on the enemy battle line. A similar attack made with aerial bombs would require from 300 to 600 airplanes passing over the enemy battle line per minute. Besides being a physical impossibility because of the limited area from which bombs can be dropped and still hit, it would be difficult for any nation to maintain such an expensive form of attack. So long as the ammunition lasts, the battleships can continue to rain this gun-propelled bombing attack at the rate of three shots per minute, whereas our 600 airplanes would have to return to their carriers and re-arm. In other words, *once the main action is joined*, the gun is by far the strongest means of offense.

It is not desired to minimize the importance of aerial bombing. In the past, however, the tendency has been to minimize the importance of the gun. From the foregoing it is apparent that, once the range has been decreased sufficiently to permit gun-hitting, it is much more effective to propel our bombs by small charges of powder than by means of heavy aircraft. It is also apparent how important aircraft spotting may be, once the main action is joined.

Coincident with the opening of the gun battle, the aerial battle will continue, and it can be imagined that this will be a real mêlée. Each commander-in-chief, endeavoring to retain aerial control of gunfire and to deny it to the enemy, will bring every possible offensive to bear. In the long run, the victory will go to the command that is best equipped and best trained.

Naval Aircraft Development and Future Trend

These tactical considerations having been outlined, we are now prepared to analyze the development of naval aircraft to date and the trend in future development. The first Navy shipboard fighting-planes were single-seaters, known as the TS, designed around the Wright Whirlwind engine. These were convertible from landplanes to twin-float seaplanes. The development by the Army Air Corps of the PW-8 and PW-9, that is, the first water-cooled fighters of high performance, resulted in the abandonment of this small plane and the adoption by the Navy of the improved type. This type was not entirely suited to naval needs, because part of its performance was obtained at a sacrifice of low landing-speed, and it was larger than desired. It was, however, adapted to carrier use by modifications and improvements.

To bring about reduction in landing-speed, the Navy undertook the development of the 425-hp. air-cooled engine through the Pratt & Whitney Aircraft Co. By a saving of about 250 lb. in the powerplant weight, the necessary reduction in landing-speed and improvement in altitude performance were obtained. The new air-cooled fighter was later modified into a single-float seaplane with lower wing-loading, giving still lower landing-speeds and better performance at altitude. All of these new fighters were much larger than the original single-seater, which was designed to meet the fundamental requirement of small size. Progress was first obtained, then, through reduction in powerplant weight.

The next advance made was the reduction in structural weight. By the intelligent use of light alloys and ingenious detailed construction, the present model of a naval single-seater was produced, designed around the Pratt & Whitney Wasp engine. This airplane, the Boeing F4B, shown in Fig. 1, is only slightly larger than the original 200-hp. single-seater, but it is about 20 m.p.h. faster than the standard single-seaters preceding it and has a tremendously improved rate of climb and service ceiling, owing to both its light weight and the introduction of supercharging. The proportion of load in this airplane is interesting. The powerplant weight, the structural weight, and the useful load are almost equal. The airplane has been designed to handle a considerable load of bombs. It therefore meets fleet needs to a very high degree.

Fig. 5—Latest Naval Patrol Flying-Boat, Type PN-12

This Type, Developed Through the Naval Aircraft Factory, Was Designed Around the Cyclone and the Hornet 525-Hp. Engines and Has All-Metal Hulls and Wings. This Type of Aircraft Has Recently Established Many Seaplane Records for Distance, Duration, Load-Carrying, and Altitude

Evolution of the General-Purpose Airplane

In the two-seater class the first airplane used was the old deHaviland. Operating from shore, it worked with the fleet to demonstrate the possibilities of aerial control of gunfire. The next step was the employment of the two-seater Hispaño-engined Vought, launched from catapults. This was replaced in turn by the Vought UO, designed around a Whirlwind engine. The possibilities of the amphibian as a fleet spotter having been demonstrated in some tactical work, the Loening amphibian was next adopted for spotting and scouting purposes. Its size, however, precluded its use in certain of the earlier catapults. When the Vought Corsair, a development from the UO designed around the Wasp engine, appeared, it replaced the Loening amphibians in the form of a seaplane as a standard fleet spotter. This plane has a performance approximately equal to that of contemporary single-seaters, flying qualities that are of the best, ruggedness that is so essential to fleet work, compactness that enables it to operate from the confined spaces of ships' decks, a gross weight which enables it to be launched from all types of catapault now afloat, and armament and gas capacity that make it a very valuable airplane.

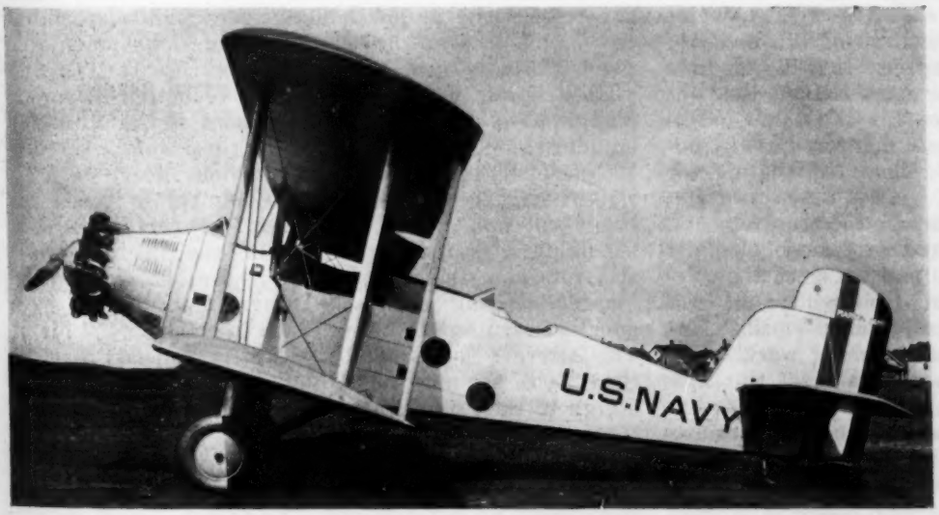


Fig. 4—Martin T4M-1 Airplane-Carrier Torpedo-Bombing Airplane

Weight of This Craft Has Been Reduced Greatly by the Use of the Hornet 525-Hp. Air-Cooled Engine and the Employment of Light Alloys. It Has Greatly Improved Performance for the Same Useful Load, and Flying-Qualities Approaching Those of the Lighter Airplanes. It is a Three-Purpose Plane, Used for Scouting, Torpedoing and Bombing

As a landplane, the Corsair, shown in Fig. 2, was adopted for carrier use in scouting squadrons. To meet the amphibious requirements, Mr. Vought, starting with the standard seaplane-float, adapted a simple retractable landing-gear to the airplane, as in Fig. 3, thus making it a successful amphibian. The Corsair, as now fitted, has the advantage that it can be flown as a straight landplane, or,

after the installation of a float, as a straight seaplane. By attaching wheels to the seaplane float, it can be converted quickly into an amphibian. With the modification, it loses little of its performance. With this universal landing-gear feature and its general suitability for spotting, scouting, and allied work, it becomes the general-purpose airplane of the fleet.

Bombers Reduced in Weight and Size

Development in the torpedo and bombing classes has been marked. The early torpedo planes were twin-float Liberty-engined seaplanes, adapted from the DH. Next came the Douglas torpedo plane, designed about the Liberty engine, and this was the basis of the Round-the-World cruisers. The conception of this type at the time was the so-called three-purpose plane, in which one airplane was intended to be used to carry a torpedo, an alternative load of bombs, or an alternative large load of fuel for scouting purposes. They were known as scouting, torpedo, and bombing planes. This multiplicity of purpose, combined with the employment of the airplane as a patrol plane, resulted in increases in size and weight to the point where the Liberty engine was no longer suitable, and a Wright Tornado engine was brought out. Around this engine the airplane was improved by transferring the bomber's cockpit from the rear seat to the forward seat, and bombing through a forward window that afforded unrestricted vision. Further additions in load to this airplane forced the adoption of the Packard 800-hp. engine.

The airplane had been growing so rapidly that it no longer met the fundamental requirement of small size, and a complete right-about-face was necessary. Here again the air-cooled engine solved the problem. At the Navy's request, the Pratt & Whitney Aircraft Co. and the Wright Aeronautical Corp. brought out their Hornet and Cyclone 525-hp. air-cooled engines. The Glenn L. Martin Co., which had been doing most of the structural work in this field, produced, at the Navy's instigation, its Design 74. By combining the reduced powerplant weight of the air-cooled engine with the ingenious employment of light alloys, the Martin company produced the T4M-1, shown in Fig. 4, which uses the Hornet engine and meets all of the needs of this type of airplane to a high degree. It is lighter than its water-cooled predecessor by more than a ton, has a greatly improved performance for the same useful load, and, combined with these factors, has flying-qualities approaching those of planes of the lighter classes.

The T4M-1 meets the three-purpose requirements. The next step in this development may readily be the elimination of the scouting requirement, since the Corsair amphibian fills this need; and this will result in a two-seater airplane that is considerably smaller, intended primarily for torpedo and bombing work. The reduction in size would enhance the value of this airplane to the forces afloat.

Development in the patrol class may be said to have begun with Rodman Wanamaker's America. The Liberty engine carried the twin-engined flying-boat type up through the F5L. The Bureau of Aeronautics, through the Naval Aircraft Factory, then advanced the type by the employment of new powerplants and metal construction. The PN-7 used the Wright Tornado engine and improved high-lift wings. The PN-8 had a metal hull built about the same Tornado engine, but was converted to the PN-9 by the use of the Packard 1A-1500 with 2-to-1 reduction gearing. The next step employed metal wings, with the latest conversion to the Cyclone and the Hornet engines, as seen in Fig. 5. These converted planes have recently established a large number of seaplane records for distance, duration, load-carrying, and altitude. The all-metal air-cooled flying-boat has therefore reached a high state of development in this Country.

These airplanes are of large size and are seaworthy. While size is, of itself, not important in this particular class, cost and other factors nevertheless direct attention toward an attempt to accomplish the same purposes with smaller aircraft. It would appear desirable now to commence a redesign around the air-cooled engines, with the idea of making the airplane as small as is possible consistent with seaworthiness, prolonged habitability for the crew, long range, and offensive characteristics. In a congested fleet-base it may frequently happen that the state of the sea or of traffic in the water-ways may restrict the employment of straight flying-boats. The adaptation of the amphibian gear and the use of the landplane field, which must be an adjunct of every fleet base, appears very attractive. This is an interesting possibility in the development of the patrol type.

Summary

To summarize: The tactical employment of naval aircraft, which is highly specialized, determines the types of aircraft used. These must be as few as is consistent with carrying out the aviation mission. All the aircraft of these types must be of minimum size and weight, and must have maximum performance under the restrictions of low landing-speed and adaptability to landplane, seaplane, and in some cases amphibian use. The development of these types has been accomplished in two basic steps: first, a reduction in powerplant weight through the development of the air-cooled engine; second, a reduction in structural weight through the use of light alloys and the ingenious design of light-weight rugged structures. The number of types has been kept down by specialization for performance in the fighter class, and by multiplying the functions while still retaining the performance in the observation and torpedo-bombing classes. Design and tactics have gone forward hand in hand, each influencing the other. The Aircraft Squadrons, Battle Fleet, consists of more than 200 of the most modern aircraft, adequate through design to the present needs, and highly trained to perform their fleet functions.

Supercharging for Sea-Level Conditions

Discussion of Taylor and Porter Annual Meeting Paper[1]

USING an 850-watt Delco-light powerplant, having a single cylinder of 2½-in. bore and 5-in. stroke, the authors made a series of tests at normal atmospheric-pressure with a supercharger to secure increased power output. The load was applied by banks of resistance lamps and by fan-blades attached to the flywheel. A water-cooled cylinder and several cylinder-heads giving various expansion-ratios were designed especially for the tests.

The results are stated and indicate the horsepower and efficiency that can be attained in automobile engines by varying, independently, the expansion ratio and the total compression-ratio. The theoretical horsepower and efficiency were computed for the conditions of the tests for purposes of comparison. The results of variations in the different factors are shown by curves, and the test results are compared with the calculated values.

In the discussion, further refinement of the apparatus used by the authors is said to be desirable and some of the results obtained are criticized. The advantages of the centrifugal type of supercharger are outlined and some of the effects of supercharging on thermal efficiency are stated. A further description of the methods used is given by one of the authors, together with answers to criticisms made. One of the discussers states that the mixture temperature and the spark advance should be given consideration when fitting a supercharger to an engine, and gives the reasons therefor.

S. A. MOSS[2]:—I understand that the apparatus used in the tests described was not as suitable as could be desired, and that the authors now have available a better grade of apparatus. On this basis, the quantitative figures given need not be discussed. The company I represent has furnished superchargers for aviation, racing-car and automobile engines, and the power increases which are being obtained for a given amount of supercharging are very much more than those indicated in the paper. This undoubtedly is due to the disabilities of the apparatus available at the time the paper was written and will, of course, be removed when apparatus more nearly representative of commercial conditions is used.

The data given seem to establish conclusively the fact that there is an appreciable gain in power, due to scavenging of the clearance volume with the use of a certain amount of supercharger pressure. Even with a comparatively small valve-overlap, there is an appreciable time when an excess of supercharger pressure in the intake manifold, over the exhaust back-pressure in the exhaust manifold, will serve to scavenge the clearance volume and force into the cylinder a greater weight of charge than merely corresponds to the filling of the displaced volume. There is also a gain due to decrease of dilution.

EFFECTS OF SUPERCHARGING ON THERMAL EFFICIENCY

It is to be noted that, owing to carburetion and similar difficulties, the authors do not use a measured fuel-rate but compute thermal efficiency wholly on theoretical grounds. Any such computation involves a great many assumptions. On the basis of the assumptions they have made, the authors indicate a decrease of thermal efficiency with amount of supercharging. No very exact data are obtainable from the commercial superchargers now in use, but there is good reason to believe that no such decrease of thermal efficiency has acually occurred. As the authors point out, the expansion ratio is decreased when the amount of supercharging is increased. This means that a small part of the toe of the indicator card is lost, but the net indicated pressure at the toe of the card is not very different from the equivalent of the friction pressure. Therefore, little if any power is being delivered by the engine during the portion of the stroke near the end of expansion without supercharging; hence the omission of some of this expansion is no real disability. To counteract this is the fact that a greater amount of power is obtained from a given cylinder with supercharging, so that the percentages of friction loss and jacket-water loss are decreased. On this basis, there is reason to believe that carefully made tests would show an actual increase of brake thermal-efficiency due to supercharging, based on actually measured fuel-rates.

It is to be noted that great variations in test results can be obtained on account of improper carburetion, improper spark-setting and the like, so that each of these items must be adjusted in the best way before any conclusion regarding supercharging is drawn.

The authors omit all mention of an important gain due to the use of centrifugal superchargers; that of improved vaporization because of passing the gasoline through the impeller and the diffuser. This gain, as much as the increase of power as discussed by the authors, has led to the commercial use of superchargers in many aviation engines.

Some of the computed results in the paper are on the basis of 60-per cent efficiency for the supercharger. This is probably proper for many designs; but centrifugal superchargers specially designed for the purpose to which they are applied are regularly giving efficiencies of 70 per cent or more.

L. M. PORTER:—We did not consider any particular design of supercharger, but merely tried to discover

[1] The paper was printed in the February, 1928, issue of THE JOURNAL, p. 195. A synopsis of the paper and the discussion is printed herewith. C. Fayette Taylor is an associate professor at the Massachusetts Institute of Technology, Cambridge, Mass., and L. Morgan Porter is a junior mechanical engineer at the aeronautical engineering laboratory of the Naval Aircraft Factory, Philadelphia. Formerly, Mr. Porter was an instructor in aeronautical engineering at the Massachusetts Institute of Technology.

[2] Thomson Research Laboratory, General Electric Co., West Lynn, Mass.

what happens in an engine cylinder with a positive pressure on the carbureter. Some other tests were made at the Massachusetts Institute of Technology on the basis of a centrifugal blower as a rotary induction-system on a six-cylinder Chrysler engine, which materially helped the distribution. We used a single-cylinder engine for the tests described in the paper and, therefore, distribution is eliminated.

P. M. HELDT[3]:—I cannot agree with Dr. Moss that the efficiency is maintained and even increased when a supercharger is used. The final compression-pressure is limited by the detonating qualities of the fuel, and if a supercharger is used and compression takes place partly outside of the working cylinder, the expansion ratio, which determines the thermal efficiency, is decreased. Loss in thermal efficiency therefore cannot be obviated.

C. P. GRIMES[4]:—While working with Dr. Moss at Pikes Peak, we were able to develop from the Liberty-12 aircraft-engine as much horsepower at an altitude of 14,900 ft. as would be expected at 2000 ft. below sea level with an economical consumption of gasoline. Dr. Moss's "turbo booster" was driven by the exhaust gases from the engine at 26,000 r.p.m.

FURTHER DESCRIPTION OF METHODS

C. F. TAYLOR:—In the supercharging work at the Massachusetts Institute of Technology, we are not trying to prove or disprove the merits of any particular kind of supercharger. Our work is directed along fundamental lines, to show what the underlying factors are in this question of supercharging, and we leave it to the commercial interests to develop the various kinds and types of supercharger. This particular work was designed to show the effect on supercharging of changing the expansion ratio. We purposely avoided anything which would bring in variables like the mixing effect of the supercharger. That was definitely ruled out. We tried to reduce the variables to the smallest number possible. In the paper, we said very little about brake horsepower and, at the beginning, we stated that the results were based on indicated horsepower; further, that the brake-horsepower results would depend on the friction characteristics and the mechanical efficiency of the apparatus involved. Dr. Moss is correct in saying that, under conditions where the engine had a very high friction-loss, one might get a higher brake thermal-efficiency with supercharging than without; however, I believe that is a very unusual situation. In general it will be found, as we found, that efficiencies go down with supercharging.

The theoretical curves are based on very broad assumptions. Many variables were involved, and, since the test results were subject to some error, it seemed hardly worthwhile to spend time in plotting curves which took into account all the possible theoretical variables. Since the paper was written, however, I have analyzed the tests theoretically to see why the observed values were so different from the calculated values. After taking into account as many of the variables in these tests as possible, we still have left the variable of scavenging the cylinder due to the difference between the intake and the exhaust pressures. There is no formula by which that can be calculated without knowing much more about the details of the process than we know now.

While the theoretical curves are not representative of the best that can be done, their shape and position with relation to the actual curves is just about what we should get if we took into account all the variables with the exception of the scavenging effect. Therefore, the difference between the theoretical and the empirical curves is representative, at least in a qualitative way, of the additional power obtained due to scavenging; and this difference becomes increasingly large as the clearance volume becomes larger and as the supercharging pressure increases.

It is interesting to note that, at the small clearance-volume high-expansion ratios, the experimental results are actually less than the theoretical ones. Evidently the effect of scavenging must be a great deal less when the clearance volume is small than when it is large. This matter interests me with particular reference to the 91-cu. in. racing automobiles, because all of them use very high expansion-ratios. From these tests it seems that, if the expansion ratio of the cylinders were lowered, they might give a considerably increased power-output.

It is probable that the valve timing of the engine will have a marked effect on scavenging. Valve "overlap," that is, the holding open of the exhaust valve after the inlet valve is opened, would evidently assist greatly in scavenging when the inlet pressure is higher than the exhaust pressure, which is the case with supercharging. The Delco engine used in these tests had an "overlap" of 14 deg.

The valve timing used in these experiments is approximately as follows: Intake opens 27 deg. after top center and closes 78 deg. after bottom center. The exhaust opens 12 deg. before bottom center, and closes 41 deg. after top center. It is admitted that this is a very poor valve-timing; but, owing to the great inaccuracy of the camshaft, this was the best that could be obtained. The compression and expansion ratios are computed for the full piston-travel.

MIXTURE TEMPERATURE AND SPARK ADVANCE

DAVID GREGG[5]:—The data presented in the paper are of interest and value to everyone who is experimenting with superchargers. In the actual fitting of the supercharger to an engine, however, the two additional factors not covered by the paper, mixture temperature and the spark advance, should be given consideration.

In any given engine, using a given grade of fuel, detonation depends on both the final temperature and the final pressure of the mixture; but each is important. An engine that is close to the detonating point can still be supercharged to a certain extent by cooling the mixture between the supercharger and the engine, so that the final mixture-temperature does not exceed that of the unsupercharged engine. In any actual installation a certain amount of intercooling occurs, as the supercharger is usually built with cooling fins and the manifolds often are ribbed to help dissipate the heat. There is also a small additional amount of cooling due to better vaporization of the fuel as it passes through the supercharger. A properly designed intercooler would, of course, provide a still lower mixture-temperature.

[3] M.S.A.E.—Engineering editor, *Automotive Industries*, Philadelphia.

[4] M.S.A.E.—Owner, manager, Grimes Brake Engineering Service, Syracuse, N. Y.

[5] M.S.A.E.—Research engineer, A. C. Spark Plug Co., Flint, Mich.

As, for practical operation, any engine must be kept below the detonating point, the amount of spark advance is of importance. Tests were made more than a year ago to determine the possible gain by supercharging without decreasing the expansion ratio of the engine. A single-cylinder test-engine was used, and the compression was raised and the spark retarded to control detonation until the maximum power was obtained. In other words, an additional increase in compression with its accompanying reduction in spark advance to control detonation produced no additional power. This was taken as the maximum-power point of that particular unsupercharged engine. The engine was then supercharged, with gradually increasing pressures, and the spark was retarded further to control detonation. It was found that the best results were secured at a pressure close to 4 lb. per sq. in. above atmospheric pressure, and that by means of the spark alone detonation could be controlled up to 6 lb. per sq. in. above atmospheric pressure. At the former figure, the horsepower increase was more than 30 per cent, with practically no change in the specific fuel-consumption. Above a gage pressure of 4 lb. per sq. in., the specific fuel-consumption gradually increased.

The actual results obtained on two supercharged engines are of interest. Both were six-cylinder automobile-engines of about 180-cu. in. displacement, and both were supercharged by vane-type superchargers at pressures varying between 3 and 6 lb. per sq. in. Standard compression-ratios and standard valve and ignition timing were employed. Ethyl gasoline was used as fuel, to prevent detonation, and the spark was retarded when necessary.

On one engine, a 55-per cent increase in net horsepower was obtained; on the other, a 69-per cent increase. Both engines were run on the dynamometer for considerable periods and were then installed in cars for road test. The performance of the car supercharged on the road is very interesting. In ordinary driving one has the impression of using second gear all the time, as the car is very sensitive and accelerates extremely rapidly; in fact, tests made for hill-climbing and acceleration ability were almost 100 per cent better than with the unsupercharged car.

The Internal-Combustion Engine

IN the light of present knowledge the highest thermal efficiency is obtained in gas or gasoline engines when the cylinder is between 3 and 6 in. in diameter. The highest thermal efficiency ever recorded by any heat engine, namely 39.5 per cent on the net shaft horsepower, was obtained on the Napier racing aeronautic engine which won the Schneider Cup trophy in 1927. The highest thermal efficiency ever recorded on a gas engine using town gas was obtained by A. F. Burstall, at Cambridge University, on a high-speed variable-compression engine of only 4½-in. bore; while almost, if not quite, the highest thermal efficiency ever recorded in a Diesel engine, namely 38.8 per cent on the net shaft horsepower, was obtained by the Royal Aircraft Establishment on a high-speed Diesel engine of 8-in. bore running at 1000 r.p.m.

High-Speed Diesel Engines

Quite recently a considerable number of high-speed Diesel engines have been constructed to run at speeds up to 2000 r.p.m., and it is surprising how few technical difficulties have been encountered. How far the saving in cost of fuel will compensate for the dirt and smell inseparable from the use of heavy oil remains to be seen. Recent developments on cracking plants indicate that nearly 60 per cent of the crude oil at the oil well can be converted into gasoline, and it is only because there is as yet but a relatively small demand for the residue that the Diesel or the oil-fired engine can show any substantial advantage in fuel cost. It is evident that, if the Diesel engine were developed to an extent comparable with that of the gasoline engine, its advantage in the way of lower fuel cost would soon disappear. Today there is practically nothing to choose between the production cost of gasoline and fuel oil, and the relative price is governed by demand, not supply. There remains, of course, the difference in fire risk, but this is greatly exaggerated, and is really serious only at sea.

The lightest engine yet made, namely the 900-hp. Bristol Mercury aeronautic engine, weighs exactly 11 oz. per hp., complete with all its auxiliary gear, while the average weight of radial aeronautic engines today is 1.4 lb. per hp. or just half of what it was 10 years ago. The normal maximum output of a commercial engine 20 years ago was approximately 6 hp. per liter of cylinder capacity; 10 years ago it had risen to 12 hp.; and today it is well over 20 hp.; yet to all outward appearances the engine of today differs but little from that of 20 years ago. In this short period it has been learned how, by purely detail design, to increase the efficiency by more than 50 per cent and the speed by more than 120 per cent.

While the small high-speed engine requires more frequent overhauls, the aggregate cost and the aggregate loss of working hours due to these overhauls will be substantially less over any given period of time than it will be for the low-speed engine. In addition, the small high-speed engine is almost immune from failures due to heat stresses in the material, is much cheaper in first cost, occupies less space, and is more easily installed.

Speed-Limiting Factors

The speed of engines today is limited by: (*a*) breathing capacity, (*b*) the dissipation of heat from the connecting-rod big-end bearings, and (*c*) the mechanical operation of the valves. The breathing capacity can be almost doubled, if necessary, by employing a double row of valves along the engine and by using two camshafts, but so doing brings the effect of (*b*) and (*c*) into play. By using roller-bearings or floating bushings, the friction and heat-flow from the big-end bearings can be minimized; and, by mounting the camshafts directly against the valves, the mass to be accelerated can be reduced. By such means the maximum power can, if necessary, be attained at piston speeds exceeding 4000 ft. per min.; but the piston speed of the simplest form of high-speed engine—with plain bearings and a single camshaft as near the crankshaft as possible—is limited to about 2500 ft. per min, for maximum power.—*Modern Transport.*

Alloy Steels and Their Application in the Automotive Industry

By Dr. Birger Egeberg[1]

Pennsylvania Section Paper — *Illustrated with* Photograph

After outlining the progress of research in the development of the alloy steels, the author says that alloys of steel containing nickel, chromium, and nickel and chromium, are the most important to the automotive industry, which is especially interested in alloys containing up to 5.0 per cent of nickel and up to approximately 1.5 per cent of chromium, with the carbon content ranging from 0.10 to 0.50 per cent. The additions of these amounts do not materially change the nature of the metallographic constituents, but the elements exert their influence on the physical properties largely by altering the rate of the structural changes.

In straight carbon-steel, especially of large sections, it is not possible by quenching to retard the austenite transformation sufficiently to produce as good physical properties as are desired. The addition of a small percentage of the alloying elements under consideration makes it possible to retard the transformation more effectively and hence to produce better physical properties. Steels of these types show only slightly better non-corrosive properties than straight carbon-steels, and the reason for their wide use is the high physical-properties which will be brought about by heat-treatment. A detailed discussion of a so-called high-carbon Krupp type of steel containing about 1.5 per cent of chromium, 4.0 per cent of nickel and 0.30 per cent of carbon is given.

By increasing the content of nickel, the transformation range is finally lowered to a point below normal atmospheric temperature. Not even the change from austenite to martensite will take place, and the alloy steel will, therefore, be comparatively soft. About 25 per cent of nickel is required to produce the desired effect, and steels are produced which are not used exclusively because of their physical properties, but on account of their non-corrosive, non-scaling and heat-resisting qualities. Similar properties are found in silicon-chromium steels, in chromium steels of high nickel-content, in chromium-tungsten steels, and in the high-chromium steels, the last mentioned being called stainless steel. It is stated also that the alloy steel to select is in many cases determined wholly by price, and in other cases with regard to what physical properties are desired together with the so-called stainless properties. Finally, consideration must be given to the corrosive agents with which the alloy steel will come into contact. Details concerning the mechanism of corrosion are given, and an explanation of why it is that certain types of alloy steel are more stain resisting than others is made.

Technical details relating to transverse and bending tests, and to the corrosive and non-corrosive properties of the alloy steels, are the main topics of the discussion which follows the paper.

THE alloy steels of greatest importance to the automotive industry are those alloyed with nickel, with chromium, and with both nickel and chromium. By adding 1 to approximately 45 per cent of nickel to straight carbon-steel, a wide variation in both physical and chemical properties is obtained. Chromium acts in a similar way, the most useful range being from 1 to 16 per cent. When both nickel and chromium are added to steel, the alloy will to a certain extent combine the specific influence of both elements. In nickel and chromium we have, therefore, the means to produce steels fitted for a large variety of engineering purposes.

The automotive industry is especially interested in the lower alloys containing up to 5.0 per cent of nickel and up to approximately 1.5 per cent of chromium, with the carbon content ranging from 0.10 to 0.50 per cent. The additions of these amounts do not materially change the nature of the metallographic constituents, but the elements exert their influence on the physical properties largely by altering the rate of the structural changes. In straight carbon-steel, especially of large sections, it is not possible by quenching to retard the austenite transformation sufficiently to produce as good physical properties as are desired. The additions of a small percentage of the alloying elements under consideration make it possible to retard the transformation more effectively and hence to produce better physical properties. These types of steel will show only slightly better non-corrosive properties than straight carbon-steels, and the reason for their wide use is the high physical-properties that will be brought about by heat-treatment. The actual figures in regard to tensile strength and elongation obtained after various heat-treatments are available in engineering handbooks.

Most test results refer to 1-in. round bars or to similar sizes. After heat-treating such a size, we find only a slight difference in the pulling test whether the steel contains 2, 3 or 4 per cent of the alloying elements. To judge from this we could be misled to believe that it was an unnecessary luxury to pay for a 4-per cent alloy when a 2-per cent alloy would give the same physical properties. The fact is that 2 per cent is not enough to retard sufficiently the austenite transformation in the center; therefore, when the size is increased, it also is necessary to increase the amount of nickel and of chromium to obtain the same high phyical-strength.

This effect can, to some extent, be obtained also by

[1] Metallurgist, International Silver Co., Meriden, Conn.

increasing the carbon content; but it should be borne in mind that carbon exerts its influence in a different way. Its influence is to change the amounts of the metallographic constituents relatively to one another, as the amount of pearlite will increase by rising carbon-contents. On the other hand, chromium and nickel affect the steel by retarding the transformation of austenite during cooling. Both ways will produce a stiffer and stronger steel, but would we expect these widely different ways to be equally desirable? Endurance tests have mostly shown the higher-alloyed steels to be superior, and I believe in low-carbon high-nickel content, at least in cases in which high ductility is required.

When heat-treating nickel and chromium-nickel steels, advantage can be taken of the depression of the Ar-point, or critical point of cooling. Further, the critical point of heating, Ac, will be depressed continually to some extent by increasing the amounts of nickel; but, in the range we consider for the present, up to 5 per cent of nickel, this depression is of little practical importance because the structural changes occur at such a slow rate, due to the natural sluggishness of the steel, that heating to temperatures fairly high above the critical point is desirable to accomplish in a short time what otherwise would cause unnecessary delay.

Depression of the Critical Point

The depression of the critical point on cooling is much greater and of much more importance to the steel treater, as he can take advantage of a low quenching-temperature if he so desires, thus minimizing both cracking and warpage. But he never takes this advantage, and therefore I believe he is missing something of real importance. Consequently, I shall present this subject somewhat in detail, illustrating it by a chromium-nickel steel containing about 1.5 per cent of chromium, 4.0 per cent of nickel and about 0 3 per cent of carbon, which is known as a high-carbon Krupp-type steel.

When plotting the heating and cooling curve for this steel, the upper critical point was found to be at a temperature of 1450 deg. fahr. and that on cooling at 750 deg. fahr., the difference being 700 deg. fahr. When quenching this steel, no consideration is made for the large hysteresis. It is hardened by heating it to 1550 deg. fahr., which is about 800 deg. fahr. above the transformation point on cooling, and quenching in oil or air, depending upon the size.

We are accustomed to figure the quenching temperature in relation to the critical point on heating, because this relation has an influence upon the strength and the toughness of the quenched steel, and this method is entirely justified in cases in which the critical points on heating and on cooling are close together. In steels, however, where the Ac-point and the Ar-point are far apart, as in the chromium-nickel steel in question, it may be worthwhile also to consider the relation between the quenching temperature and the critical point on cooling, as this relation might have considerable influence upon the hardening results, especially in regard to toughness, warpage and internal strains that might cause cracking of the steel and the like.

There once came to my attention some large rings or rolls made from the steels mentioned, and I hardened them in oil as just described from a temperature of 1550 deg. fahr. The result was that most of them cracked. They did not crack, however, until on their way to the consumer and, in time, we received from him a complaint not only about the charge for the heat-treatment but because we had the courage to send the broken pieces back to him. Some new rings were made and, meanwhile, experiments were begun to investigate the possibility of a quenching temperature closer to the Ar-point.

Standard tensile-strength test-specimens were made up which were all heated together to a temperature of 1525 deg. fahr.; thereupon, two samples were removed from the furnace and cooled in quiet air. The furnace was at that time shut off and the remainder of the samples were allowed to cool down with the furnace to a temperature of 1300 deg. fahr. At this temperature, two more samples were removed and quenched in air. After a further drop in temperature to 1110 deg. fahr., another set of samples was removed from the furnace, and so on down to 750 deg. fahr., the critical point, at which temperature the last two samples were quenched. All samples were then ground to 0.505-in. diameter and one of each treatment was pulled in a tensile-testing machine. A tabulation of the results is given in Table 1.

TABLE 1—RESULTS OF INVESTIGATION OF QUENCHING TEMPERATURE[2]

Quenching Temperature, Deg. Fahr.	Maximum Tensile-Strength, Lb. per Sq. In.	Percentage of Elongation in 2 In.	Reduction of Area, Per Cent	Brinell Hardness
1,525	239,000	1	17.3	495 to 512
1,300	244,000	10	26.7	512
1,110	237,500	13	34.6	495
930	242,500	13	38.7	495
840	245,000	14	44.7	500
750	229,000	8	...	512 to 460

[2] All samples were heated to a temperature of 1525 deg. fahr. and thereupon were cooled slowly with the furnace to the temperature given in the first column, being then quenched in air at that temperature.

It will be noticed that gradually decreasing the quenching temperature from 1525 to 840 deg. fahr. causes a steady increase in elongation and in reduction of area, but that the Brinell hardness and the tensile strength remain constant until a temperature of 750 deg. fahr. is reached. At this temperature the critical point on cooling has been reached, causing a drop in hardness and in tensile strength. The toughness figures at this point have also dropped, owing to an uneven hardness, the middle of the tensile test-specimens being harder than at the punch marks because of the retarded cooling effect of the larger-dimensioned heads. Due to this effect, the sample cannot stretch equally over its whole length, which explains why it breaks with less elongation than that which corresponds to the tensile strength.

The remaining samples, one from each of the foregoing treatments, were drawn to a temperature of 480 deg. fahr. and pulled. The results were all identical. No matter which of the heat-treatments the sample had undergone, it always showed after drawing to a temperature of 480 deg. fahr. a maximum tensile-strength of approximately 240,000 lb. per sq. in., an elongation of 15 per cent in 2 in., a reduction of area of 45 per cent, and a Brinell hardness of 477 to 495. This indicates that the differences found between the samples in Table 1 probably are caused only by strains set up during air-quenching of samples from the higher temperatures;

and that such strains are not introduced—or are at least of a comparatively small magnitude—when the steel is slowly cooled to near the Ar-point before it is quenched. The low magnitude of the strains can be explained by smaller dimensional changes taking place when quenching from the low temperatures.

Advantage of Low Quenching Temperature

When heat-treating pieces of large dimensions or of intricate shape, the advantage of the low quenching-temperature is evident. By dropping the quenching temperature of the steel from 1525 or 1550 deg. fahr. to the neighborhood of the thermal point on cooling, it is possible to obtain the maximum hardness and tensile strength that the steel is capable of giving combined with a 13 to 14-per cent elongation, whereby hardening cracks are eliminated. When quenching, on the other hand, from a temperature of 1550 deg. fahr. or a similar temperature above the Ac-range, the steel will not be any harder or stronger and the elongation will be so low that hardening cracks are likely to develop. Besides, there is the question of warpage or volume change. It is anticipated that the low quenching-temperature will give less dimensional change than the high quenching-temperature. This part, however, was not investigated thoroughly and it shall, therefore, be stated only that the steel, when given the low quench, comes in the class with the so-called non-changeable steels. Further, the possibility of quenching articles of slender shape at a heat below visible red, when the steel is stiff enough not to bend when handled, is of undoubted value in many cases, especially when such treatment of the steel in question is able to develop Brinell hardness anywhere from 512 and down to 228, depending upon the temperature at which it is subsequently drawn.

It is felt that the described hardening method might be of value also for other steels in which a considerable thermal hysteresis exists, and the method can be applied also to such steels when case-carbonized. In fact, I can see no reason that the carbonizing itself cannot be undertaken at the low heat; naturally, after the steel has at first been heated through its upper critical-point. If difficulties due only to cracking, exfoliation, or volume change have to be guarded against, and if the question of bending caused by handling at a red heat does not need to be considered, two furnaces probably would be of advantage; one heating furnace in which the steel is heated to the initial temperature above the Ac-point and from which the steel is transferred into a second furnace kept at a constant lower temperature in the neighborhood of the Ar-point, where the steel is kept until it has acquired this temperature and is ready for the quench. It was found that a cooling time of 4 hr. from 1525 deg. fahr, down to the desired quenching-temperature had no influence upon the results. Any longer cooling-time was not experimented upon.

When quenching from these low heats close to the transformation point on cooling, which is at a black heat, the thermocouple alone has to be relied upon. Steel treaters do not like this; they are accustomed to harden from a red heat, and they want to check the temperature and the evenness of the heat by the eye. It is therefore with great comfort that we note from Table 1 that a faint-red quenching-temperature of around 1000 deg. fahr. seems to do just as well.

The steel I have taken as an illustration is not of the type most commonly used in the automotive indutry. It has, however, such a great difference between the critical points on heating and on cooling that it serves well to illustrate the point I wanted to bring out. But all the chromium-nickel steels and the nickel steels show a similar hysteresis to a greater or lesser extent. The higher the percentage of alloy is, the larger will be the hysteresis.

Lowering of the Transformation Point

We have up to now considered steels with no more than 5 per cent of nickel. When cooled slowly they are pearlitic and it is necessary to quench them in water, oil or air, to develop desirable physical properties. When the amount of nickel is steadily increased, the transformation point is gradually lowered more and more. The rigidity of the steel treated by the low temperature will increase, decreasing the rate by which the structural changes take place and, finally, a point is reached at which no quenching is necessary; the steel will be martensitic even after slow cooling. The necessary amount of nickel to produce this effect will vary with the carbon content. When only small amounts of carbon are present, a high percentage of nickel is required, and vice versa. This has been taken advantage of by a Frenchman claiming a patent for a steel containing 7 per cent of nickel and 0.15 per cent of carbon, to be used for case-hardening purposes. This steel is pearlitic and can be machined fairly easily but, when increasing the carbon content during carbonization, the outer layer will come into the martensitic range and the surface will be hard even after slow cooling. The advantages should be freedom from cracking and distortion. Although theoretically of interest, the steel has never been used to any extent. The same is true of all the nickel steels that become martensitic upon slow cooling.

By a still further increase in nickel, the transformation range is finally lowered to a point below normal atmospheric-temperature, and not even the change from austenite to martensite will occur; therefore, they will be comparatively soft. About 25 per cent of nickel is required to produce this effect, and we shall arrive at steels that are not used exclusively because of their physical properties, but on account of their non-corrosive, non-scaling and heat-resisting qualities. We will find similar properties in silicon-chromium steels, high nickel-chromium steels, chromium-tungsten steels and in the straight high-chromium steels. The last mentioned we are now accustomed to call "stainless steel." The one to select is in many cases only a matter of price. In other cases we have to consider what physical properties we want together with the stainless properties. Finally, we must consider with what corrosive agents the steels will come into contact, as none of the steels just mentioned are equally resistant against all corrosive conditions.

The Mechanism of Corrosion

In dealing with the non-corrosive and heat-resisting steels suitable for use in an automobile, I shall concentrate upon the mechanism of corrosion and try to explain why it is that steels of certain types are more stain-resistive than others.

From the viewpoint of corrosion, the metals can be classified into three groups, the first two of which in-

clude metals and alloys that are able to withstand oxidizing or corroding mediums. The third group contains the metals that invariably will rust and be eaten away. The non-corrosive metals are separated into two groups because of the different ways in which they resist corrosive agents. Some, like gold, platinum and other rare metals, owe their non-rusting properties to their chemical indifference. The scarcity and high price of such metals prevent them, however, from being used as non-rusting materials in the industry. Non-corrosive metals in the second group owe their properties, not to any chemical indifference of the metal, as such, but to the characteristic that generally is called "passivity."

We understand the term "passivity" to mean the formation of a thin skin of oxide or rust on the surface of the metal, which skin is so homogeneous that it prevents air, water and other corroding mediums from coming into contact with the underlying metal and thereby renders it passive against further attack. Lead and aluminum are good examples of passivity. Lead ordinarily is coated with a grayish film and, when cut with a knife, the bright metal itself is exposed. The film on aluminum is not so apparent. We are accustomed to look upon aluminum as a non-rusting metal. This metal is, however, when not made passive, so active that it reacts violently with water and even with the humidity of the air, forming aluminum hydroxide. In spite of this, we use it extensively for kitchen utensils that come into contact with water, but this is made possible only by the passivity of the oxide film with which it covers itself. The only requisite is that conditions prevail which will form such an oxide; but this does not present a difficulty because, in nature, oxidizing conditions are predominant. The oxidizing condition, which is the saviour of aluminum, is the ruin of iron. Iron also forms an oxide, but it is not a tight homogeneous skin; it does not close out the corroding agents or it becomes dissolved by them. They come into contact with both the metal and the rust at the same time and a galvanic action is thus established which, besides the dissolving power of the agent under consideration, will cause progressive corrosion of the iron.

We see, then, that the oxide which forms on aluminum prevents further corrosion but that, in the case of iron, it increases corrosion. We also see that, aside from the rare metals, all industrial metals and alloys like copper, nickel, zinc, iron, stainless steel, bronze, brass and so forth, rust or corrode. The clean metal surface of all will always rust or corrode. Whether the metal is to be all eaten up in time, like the iron, or the oxidizing is to stop, thereby leaving the article intact often for centuries, depends wholly upon the form of the first rust, whether it is a tight skin covering the entire article or not. How large an effect this seemingly small difference has is illustrated by some figures from the iron industry. It has been calculated that about 20,000,000 tons of iron are rusting away yearly, which is about one-half of the yearly production in the United States. If iron covered itself with a tight skin of rust, thus preventing further corrosion, we could reduce our yearly production by 20,000,000 tons, which would be a tremendous saving. The statements I have made about the problem of corrosion I believe to be in agreement with the facts and theory that are generally accepted.

Resistance of Non-Corrosive Steels

Considering the non-corrosive steels specifically, we might ask why it is that they are not equally good if it is true that they all form a tight skin around the metal. Is it because the skin formed on different steels varies in quality? And why is it that the surface film of the stainless chromium-steel is highly resistant to nitric acid and easily attacked by sulphuric acid, and that the nickel steels behave in an opposite manner? The answer must be that the film formed on different steels has a different chemical behavior. It is not to be supposed that the film formed on a nickel steel is of the same composition as that formed on a chromium steel; and, being of different chemical composition, they will also behave differently when acted upon by chemicals. If the film is destroyed or dissolved, there naturally will be no protection; therefore, not only the formation of a homogeneous surface-skin is needed, but the stability of this film against those gases or fluids that we want the steel to stand up against must be considered.

Effect of Contact with Other Metals

Another important matter for consideration in connection with the suitability of stainless steels is that of the metals with which they come into contact. I once made the following experiment to establish the influence of a piece of straight carbon-steel when brought into contact with stainless steel and acted upon by corroding agents. A 1-per-cent-carbon steel and a stainless steel of the 14-per-cent chromium and 0.30-per-cent-carbon type were selected for the purpose, both being in annealed condition. The specimens were cylinders 1 in. high and 1 in. in diameter, and the results are stated in grams per centimeter squared per year. When the specimens were suspended separately in sea water, the losses due to corrosion were, for carbon steel, 0.0752, and for stainless steel, 0.0212; the total being 0.0964. When the two samples were placed in contact with each other in sea water the losses were, for carbon steel, 0.1067, and for stainless steel, 0.0024; the total being 0.1091. In the latter case, the amount dissolved from the stainless steel is decreased to approximately one-tenth, but the carbon steel has suffered increased attack to such an extent that the sum of the dissolved metals is larger when in contact with each other than when acted upon separately. It is evident from this that carbon steel will protect stainless steel from the attack of sea water. These figures are not accidental but are typical whenever an anodic material is placed in contact with stainless steel and acted upon by corroding agents. On the contrary, when stainless steel is in contact with a material that is cathodic to it, the results will be reversed and increased corrosion will be suffered by the stainless steel.

Considerations of the foregoing kind must be made in most cases in which stainless steels are employed and, in order that neither the stainless steel nor the other metal in contact with it should suffer increased corrosion, it is necessary that the electrolytic potentials of the two metals be equal so that no electric current will be generated and each of the two metals will resist corrosion as if they were acted upon separately. But a condition of equal electrolytic potential is very rare, and we have mostly to be satisfied with potentials that are fairly close to each other. The

smaller the difference is, the weaker will be the current and the smaller will be the influence of the two metals upon each other.

To start an electric current between two metals and thus begin the associated corrosion, it naturally is necessary for the current to find some way back to the place from which it started and thereby close the circuit. If the circuit is not closed, the one metal will not influence the corrosive properties of the other, even though they are in contact with each other. As an example from my own field of work, a certain table-knife has a hardened stainless-steel blade soldered into a hollow shell made from a non-ferrous metal, and the handle is silver-plated. A button of lead inside the hollow handle balances the weight of the knife blade; the hollow handle being made in halves which are soldered together. From an electropotential viewpoint, the whole knife is very complicated. The situation is somewhat simplified by the fact that only three different metals are exposed: the stainless-steel blade, the metallic-silver deposit on the handle, and a rim of solder where the blade is fastened to the handle. This knife will give years of service under ordinary household conditions without showing any signs of deterioration. But, as soon as it is put into a flannel bag, an electrical circuit is closed because the bag is somewhat moist, especially in summer. The knife might not be entirely dry when put into the bag and that makes the condition worse. If left in a flannel bag for any considerable length of time, the stainless blades will be badly corroded in spots. In one instance in the laboratory, a hole was eaten through the stainless-steel blade in one week when kept in a flannel bag made from a special non-corrosive material containing no acids and kept moist with distilled water. The water probably dissolved some of the dyes in the flannel, converting it into an electrolyte that allowed the current to flow from the blade to the silver handle and back again to the blade through the moist bag. In this system the stainless steel is the anode, and it is therefore attacked. The example serves to show that, in case of the possibility of a closed electric circuit, the electropotential of the stainless steel toward those metals in contact with it plays an important part.

Castings made from stainless steel or stainless iron are not used to any great extent. Table 2 gives data pertaining to the heat-treatment of castings made from Grade-A stainless-steel to obtain the best non-corrosive properties. We might judge from the figures that the cast structure is not very resistant and that the steel will be greatly improved by annealing above the upper critical-point, whereby the ingot structure is destroyed.

TABLE 2—HEAT-TREATMENT FOR BEST NON-CORROSIVE PROPERTIES OF GRADE-A STAINLESS-STEEL CASTINGS[3]

Temperature, Deg. Fahr.		Loss in Grams per
Annealing	Quenching	Sq. Cm. per Year
1,425	....	1.9425
1,425	1,750	0.4070
1,750	1,750	0.0074

[3] A 1-to-10 solution of nitric acid was used.

Causes of Rapid Corrosion

At Delhi, India, stands an iron pillar of low-carbon iron containing no alloys. It was erected 2000 years ago, and, according to all calculations, it should have been consumed entirely by rust before now; but it shows no signs of rust. The iron was made in pots directly from the ore, in one melting, whereas all modern methods employ at least two meltings; one to reduce the iron ore to pig iron in the blast furnace and a second melting in the steel furnace to convert this pig iron into malleable iron or steel. Lately, large amounts of scrap iron have been added to the pig iron in the second melting, especially since the electric furnace came into use. The scrap iron may have been remelted many times before as, with our present methods of manufacture, scrap travels a long way. The iron and steel products of today are, therefore, widely separated from the iron ore, whereas the iron of ancient times was all virgin material produced in one melting directly from the ore. This probably is one of the main reasons that modern iron reacts or rusts more rapidly than did the ancient iron.

Conservation of Basic Materials

If no scrap were used and if the alloying elements such as nickel and chromium in that scrap thereby went to waste, we should soon be without raw materials needed for the production of the alloy steels required today in the automotive industry. Our resources of iron ore and of alloys are not unlimited, and mining geologists are already busy calculating for how long a period our present ore resources will last. We may find new and rich ore deposits but, on the other hand, nobody knows what kind of highly alloyed steels and metals we may be forced to develop. At present we are just at the beginning of the alloy-steel age, which is practically only 25 years old. In the last quarter of a century we have seen developed the high-speed steels, the austenitic manganese-steel, the stainless steel and the high nickel and nickel-chromium steels, as well as all the lower alloyed steels like those used in the automotive industry. Although comparatively low in alloys, they are made in large quantities, and there is reason to believe that the tonnage of alloy steels will increase in the future. Facing such a situation, it is evident that we should use every bit of iron and steel scrap again and again by charging it into a melting furnace as soon as it has become useless in its existing shape, and that we should regain to the utmost the alloying elements contained in that scrap.

Economic Benefit of the Electric Furnace

The electric furnace performs an important part because it can adjust itself to any kind of scrap and recover from it cheaply and on a large scale valuable alloys that otherwise would be carried off into the slag and lost. This point is seldom brought home to us with the force it deserves. The steel salesman, from whom most of us gain our information, never mentions it because it is no sales point. What he is interested to demonstrate is the high quality and the reasonable price of electric-furnace steel. He is not interested in telling us that his company, in making that steel, can regain from the scrap used all the valuable alloys it contains. But this point is of great interest because it forms the basis of our future National welfare. It is comforting for the Nation to know that every bit of scrap steel, in any quantity, can be remelted economically without loss of the alloying elements, and that no additions of virgin material from the ore mines are necessary. Thus we can leave, not scrap only, but also virgin ore for those who come after us. We then real-

ize that the advantage of the electric furnace is not only to make high-quality steel at a reasonable price, but that its revolutionary achievement is one of National economy; to recover on a large scale the alloying elements in the scrap and to preserve our natural resources.

Nickel and Chromium-Plating

From 12 to 14 per cent of chromium and 25 per cent of nickel are required to produce a steel that is satisfactorily non-corrosive, which property is obtained solely by the additions. We therefore expect similar resistive properties of the elements nickel and chromium themselves, and we nickel-plate iron to protect it from tarnish and rust. Of late, chromium-plate is preferred on account of its still higher resistance against corrosive agents and its greater hardness. However, hardness should not be emphasized too much because electrodeposited metal, of the thickness regularly applied, acts no harder than the metal underneath in the way it takes marks and scratches. Any soft-metal article that has been chrominum-plated to a commercial thickness—which in many cases is merely a flash—will scratch as easily as before plating. The electroplate is broken through and the metal underneath is scratched.

A thin deposit of chromium will greatly increase the difficulty attendant on buffing and lapping operations, depending upon the color of the deposit, whether milky, bright or frosty. The three deposits having these color characteristics are of increasing hardness in the order mentioned and can be produced according to wish by modification of the current density. It is deemed uncommercial in most cases to buff after plating; therefore, the articles are buffed to the final finish before plating and, in case they are given a preliminary nickel-plate or some other coating, which often is done, this plate is buffed before the article enters the chromium-plating tank. If the electrodeposition is correctly undertaken, the chromium-plate will have the same bright finish as when the article left the buff.

In the case of several chromium-plated teaspoons in the condition in which they came from the plating tank, where they were plated separately for 10 min., 1 hr. and 2 hr., using the same current density, and on which no buffing was done after the plating, an increasing resistance against scratching with a knife is noticeable. The 10-min. plate can be scratched easily, and the 2-hr. plate can be scratched by using some force. But the increase in scratch resistance is not caused by any increase in the hardness of the chromium due to the longer time of plating; it is on account of the greater thickness of plate, which cannot be broken through so easily. Even the 10-min. plate is thicker than that commercially given ordinarily and, if deposited on a soft-metal base, it is evident that the scratch hardness, or resistance against being marked and shaved, is not great. However, if applied to a hard base, such as hardened steel, the chromium-plate acts hard toward scratchings and toward a file.

Methods of Chromium-Plating

The greatest benefit resulting from chromium-plate, which generally is applied to soft or medium-soft articles, lies not in its hardness but in its resistance against tarnish. In such case chromium is applied on top of nickel or copper-nickel coatings, especially if the base metal is made from iron or some alloy liable to rust. The thickness of a commercial chromium-plate, as well as its porosity and its electropotential toward iron, is not sufficient to make it an effective rust preventer. Underlying nickel or copper-nickel deposits are therefore applied as rust preventers, and a top coating of chromium is applied to prevent the nickel from tarnishing.

The outstanding feature of chromium-plate, compared with other metal electrodepositions, is the high amperage used, whereby large volumes of hydrogen are liberated on the cathode together with the depoited chromium. The loss in electricity is equivalent to the amount of hydrogen evolved. In this and other ways, 80 to 85 per cent of the electricity is used up, so that the cathode efficiency is only 20 to 15 per cent as compared with 100 per cent, as for example, in the deposition of silver. The high amperage brings about several disadvantageous features. Besides a brittle deposit and a loss of 80 per cent of the electricity, an unpleasant spray produced by the large volumes of gases that escape exists over the bath, which causes a loss of the plating solution. There is also a great tendency for sharp corners and outstanding points of the article being plated to become burnt, due to poor throwing-power. Finally, the contact points by means of which the current is conveyed to the article must be of such dimensions as to carry the high amperage, and this is very inconvenient when articles such as the teaspoons mentioned are to be plated all over and any spot not covered by the chromium is objectionable. Everyone who practices chromium-plating realizes that it presents a rather difficult problem. The foregoing description refers to common American practice.

Chromium-Plating Practice in Germany

A German advertisement indicates that chromium-plating has reached a higher level in Germany than it has in America, although no other country has gone into commercial chromium-plating so extensively as has the United States. The German advertisement, as translated, reads as follows, the text within the parentheses being explanatory of American practice:

(1) The plating bath operates at 20 to 50 amp. per sq. ft. (compared with 200 to 400 amp. per sq. ft.).

(2) Due to the lower current, the articles to be plated can be hung on wire (instead of clamping them more or less solidly).

(3) Because of the lower current-density, there is practically no spray.

(4) The cathode efficiency is 40 to 50 per cent (compared with 15 to 20 per cent).

(5) The throwing power is excellent. (This is a very weak statement; however, it is to be anticipated that lower current-densities give better throwing-power).

(6) Barrel plating can be done. (So far as I know, none of the chromium-plating companies in America have been able to plate chromium by the barrel method).

(7) Small generators; therefore a comparatively cheap outfit is employed.

(8) Bright deposits are obtained at a temperature of 30 deg. cent., or 86 deg. fahr. (compared with the higher temperature of 45 to 50 deg. cent., or 113 to 122 deg. fahr.).

Recent articles in the German technical literature, written by men whose statements we have no reason to mistrust and who never would use their names for the

purpose of misconstruing the truth, also indicate that Germany is far ahead of us in chromium-plating practice.

In my opinion, the difference of the German from the American practice does not constitute the advantage to be anticipated from the foregoing advertisement and from the German technical literature. So far as I have been able to ascertain, the chromium-plate applied on the Continent is of a nature that needs buffing to bring out its full luster; whereas, the American manufacturer has found it more economical to do all buffing on the softer base-metal or on the preliminary copper or nickel coatings and expects a bright, finished article directly from the chromium-plating tank without doing any subsequent buffing. Accordingly, the German advertisements and literature do not apply to what we understand in this Country as being electrodeposited chromium and, therefore, cannot be compared.

The Testing of Automotive Steels

As I have dealt only with the characteristics of nickel-chromium steels, my remarks about testing also will refer to them.

Heat-treated samples cut longitudinally from the bar stock of different heats melted to the same specification show comparatively small variations in tensile strength and toughness. Wherever a large variation in the physical properties was encountered, I have mostly been able to refer this back to variations in the heat-treatment or, more often, to variations in the chemical composition, especially to that of the carbon content. To judge, therefore, from the longitudinal test-results, all commercial and so-called "well-made" nickel and chromium-nickel steels are very even and reliable materials of construction. However, on looking further into the subject, some doubt may arise as to the evenness of the steels mentioned, as well as to the value of the longitudinal tensile-test in detecting possible variations in the material.

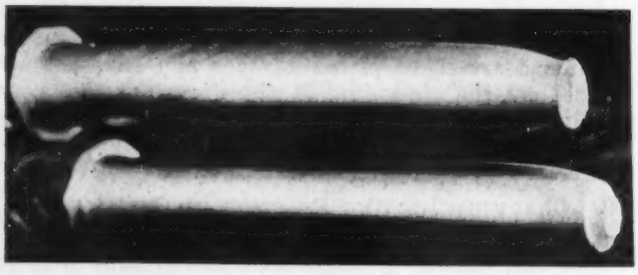


Fig. 1—Appearance of a Pulled Longitudinal Test-Specimen

The Beautiful "Cup-and-Cone" Fracture Is Evident. A Transverse Test-Specimen of This Same Steel Ruptured at only a Few Thousand Pounds per Square Inch. It Had an Elongation of 2 Per Cent in 2 In., and Showed No Reduction in Area

I have seen beautiful longitudinal tensile-test results showing the highest possible figures corresponding to the heat-treatment given and, when the same steel was tested transversely, it ruptured at one-half the expected load, with virtually no elongation or reduction of area. Fig. 1 shows the appearance of a pulled longitudinal test-specimen. The beautiful "cup-and-cone" fracture and the physical properties are evident. A transverse test-specimen of this same steel ruptured at only a few thousand pounds per square inch; it had an elongation of about 2 per cent in 2 in. and showed no reduction in area. From this it is evident that the longitudinal tensile-strength test is really of very little value. In fact, when once being accustomed to the steel one makes or uses, the Brinell-harness number will indicate all one needs to know about the longitudinal tensile-strength properties.

The thing to watch is the transverse test; that is, the transverse tensile or the transverse impact-tests. Some such transverse test is the only means, I believe, by which the quality of a nickel or chromium-nickel steel, of the types used in the automotive industry, can be ascertained. This is not merely a matter of opinion; it has been proved over a period of 5 or 6 years, during which time I made only a few longitudinal tensile-tests, although nickel and chromium-nickel steels were turned out regularly to close physical specifications. I may say, however, that the steel in question was all made in an electric furnace according to the best method we knew of at the time, and that I controlled the melting, hammering and rolling of it myself; therefore, I knew the history of each heat from the beginning to the end. Naturally, the steel consumer, the automotive engineer, does not have all that information. Besides, he might be using steels from different sources, both open-hearth and electric-furnace steels, and I do not know to what extent he is able to eliminate the longitudinal tensile-test. But I am positive that the longitudinal test alone is no true indication of the quality of the steel and that a transverse test should be made in addition.

Kind of Transverse Test Desirable

The kind of transverse test desirable depends largely upon what sizes of steel are to be tested. Sheets and large bars can be tested by means of a transverse tensile-test bar; from smaller bars, a transverse impact-specimen can be made even though it will not have the full length of the three-notched standard Izod specimen. For still smaller bars we must satisfy ourselves with a fracture test or with a cupric etch of the type recommended by Stead or by Rosenhain and Houghton. The appearance of the fracture is indicative of the figures obtained and, as the fracture is substantially the same whether a tensile or an impact test is made, it is comparatively easy after some experience to translate the results from one kind of test into another.

To make the test, the transverse tensile-specimen or impact specimen or disc to be fractured should be quenched in oil from the regular temperature for the kind of steel in question and drawn at a high temperature of 1000 to 1100 deg. fahr. A low drawing-temperature will not do for the purpose. If one has not broken discs or pulled transverse tests of nickel or chromium-nickel steels before, I guarantee that, after heat-treating them in the foregoing manner, he will be surprised at the result. The fracture has in any event more or less of the appearance of fibrous wood. It may contain other defects but I shall deal only with this woody appearance. The more woody the fracture is, the less will be the transverse impact-strength, elongation and reduction, when measured on transverse tensile-bars, and the more streaky will be the apparance of a polished sample cut in the direction of rolling and etched with Stead's or Rosenhain's cupric solutions. The etch test and the fracture are, in other words, directly indicative of the tranverse-test figures and, after some experience, it is not at all difficult to judge from the fracture what the actual transverse-test figures will be.

The easiest way is to judge the transverse-test figures in terms of percentage of the longitudinal test. If, for example, a longitudinal impact-test with the heat-treatment given shows 100 ft-lb., the transverse impact-test when given the same heat-treatment will show anywhere from 80 per cent down to 20 per cent of that figure. When the transverse fracture cannot be distinguished from that of the longitudinal specimen, the transverse impact is about 80 per cent of that of the longitudinal. When the fibrous appearance grows more pronounced, the transverse impact drops and, with the steels mostly encountered, it will be, as an average, 40 per cent of the longitudinal impact, with 55 per cent and 25 per cent as the approximate high and low limits.

For the impact test to be below 20 per cent, the woody structure alone does not suffice, and we must look for the explanation in the form of internal cracks or so-called "snow flakes," about which so much was written during the World War. Of late, the question has rather subsided, to judge from the few recent comments on the subject; but it would be entirely misleading to believe that this is due to no more "flakes" being present in steels of today. It is rather due to the fact that the metallurgist exhausted his efforts toward solving the problem.

A transverse test of some kind, even a fractured disc, tells more about the quality of nickel and of chromium-nickel steels and their physical properties in different directions than do the longitudinal tensile or impact tests most commonly applied. However, it should be understood that, to develop a fracture by which the quality can be judged intelligently, it is necessary to draw the sample at a high heat and not to draw it at the lower heat that mostly would apply to articles that are to be put into service.

Sulphur-Print and Gelatine-Paper Tests

The so-called sulphur-print test as originally developed by Heyn and Bauer was made by wetting a piece of white silk with a solution of mercury chloride in hydrochloric acid and gently pressing it upon the polished steel sample to be investigated. Both the phosphorus and sulphur compounds of the steel reacted with the mercury chloride, and formed on the silk spots of yellow-colored mercury-phosphide and dark-colored mercury-sulphide, whereby a distinction could be made between the phosphorous and the sulphur segregations in the steel by this difference in color of the spots on the silk.

Later, Bauman developed the method which now is generally termed the sulphur print by substituting a silver-bromide paper for the mercury-chloride silk. This new method has the advantage that it leaves much more sharply defined spots on the paper than were obtained on the silk. However, it has the disadvantage that phosphide and sulphide of silver are both dark-colored; therefore, the method cannot be used for distinguishing between phosphorous and sulphur segregations, since it indicates the total segregation of both. This should be kept in mind when conclusions are drawn from prints obtained by the Bauman method.

Dr. H. J. Van Royen, in collaboration with E. Ammermann, has developed recently a new method which combines the advantages of both the Bauman and the Heyn print. It is as easy to apply and gives as sensitive and sharp prints as does the silver-bromide paper and also makes it possible to distinguish between sulphur and phosphorus segregations. The method is described in a German periodical[4]. It consists in wetting a gelatine paper (manufactured by Firma Bayer, Leverkusen, Rhineland, Germany) with a mercuric-chloride solution containing hydrochloric acid. The composition of the solution is in the proportion of 10 grams of mercuric chloride, $HgCl_2$, to 20 cc. of hydrochloric acid, HCl, to 100 cc. of water, H_2O. The paper is soaked in this solution for 2 min.; it is then applied to the sample in the usual way for 3 to 5 min. After removing, the paper is rubbed gently under water with a piece of cotton wool and then washed in water for 1 hr.

The gelatine paper can be made from the regular photographic silver-bromide paper by removing every trace of silver in an hypo fixing-solution. After drying, it can be treated in the foregoing way just before use, or also soaked in a mercury-chloride solution, dried and stored ready for use after moistening with hydrochloric acid only.

The original article[4] by Dr. Van Royen is beautifully illustrated and shows each specimen etched in four different ways; namely, with copper ammonium chloride, with a cupric solution similar to Stead's solution, by Bauman sulphur-print, and by the gelatine-paper print just described. The prints show the merits of each solution compared with the others. They plainly illustrate that the present so-called Bauman sulphur-print in some cases registers segregations where the Van Royen print indicates only normal amounts of sulphur to be present. The Bauman print in such cases registers pure phosphorus segregations, which is borne out by the two copper-solution etchings; therefore, it does not seem warranted to call it a sulphur print. That this is not taken notice of to the extent it deserves is evident throughout the technical literature. Only recently Davis and Peters, in their article entitled Studies of Internal Fractures in Bars[5], mention the use of the darkness obtained on silver-bromide paper for judging the sulphur content of the steel at a particular spot. I shall not dispute that it might be sulphur in the case they discuss. Considering, however, that phosphides and also mixtures of phosphides with sulphides will produce a similar darkness on the silver-bromide paper, it is evident that care should be exercised in drawing too decided conclusions in regard to the sulphur content. It is also evident that our terminology should be revised, and the following revision is proposed:

(1) The present so-called sulphur print on silver-bromide paper should be called Bauman print, after the originator, and used as an indication of the segregations, either sulphur or phosphorus, or both, that are present in the steel.

(2) The new developed print on mercuric-chloride paper should be called Van Royen print and used as an indication of sulphur segregations only.

I take special pleasure in mentioning these results because Dr. Van Royen was my superior at the Phoenix Steel Works in Germany 15 years ago.

[4] See *Stahl und Eisen*, April 14, 1927, p. 631.
[5] See *The Iron Age*, Aug. 18, 1927, p. 400.

THE DISCUSSION

DR. FRANCIS B. FOLEY[6]:—Many automotive parts are much too small in cross-section for us ever to be able to get any transverse tests; for example, it would be rather difficult to get transverse tests from axles. In any steel that has been subjected to a considerable amount of reduction in hot-working there is bound to be a great difference in ductility of transverse and longitudinal test-bars, the ductility always being lower in the transverse test-bar. However, if the low ductility is accompanied by a marked lowering of the tensile strength and elastic limit, it shows that the steel contains some imperfections of the nature of cracks, foreign inclusions or "flakes," which account for the lower physical-properties. Such imperfections should be taken into account when mention is made of low transverse physical properties.

Consideration should be given to the way in which a member is to be stressed in service. Occasions arise in which very high longitudinal ductility is highly desirable and gives a stronger member than one that may be of equal ductility longitudinally and transversely. With respect to fiber, a piece of steel can be likened to fibrous wood. It will support a transverse load much better if the fibers are longitudinal than if they run in a direction parallel to that of applications of the load. I call attention to the great difficulty one has in breaking a piece of wrought iron by bending across the fibers; yet wrought iron has very low transverse ductility. Structural members should therefore, if possible, have some working done in a direction normal to that in which the members will be stressed.

R. W. A. BREWER[7]:—Owing to the difficulty of testing the usual forms of steel as used in automotive practice, it seems that a very simple solution would be to make bending tests, if the bending test would give a very good indication of what was happening transversely. The slippage along the horizontal plane would manifest itself, I believe.

E. W. TEMPLIN[8]:—With reference to all-steel body-construction for passenger-cars and motorcoaches, what are the non-corrosive qualities of stainless steel such as might be used in body structures?

C. C. TRUMP[9]:—Non-corrosive steels have been used in tank roofs, where the exposure to corrosion is severe on account of moisture, sulphurous gases and temperatures which are just right for corrosion. The worst corrosion always occurs when metals of different electrical properties are in contact. In automobile-body construction, the metals should be as nearly as possible electrically alike where they come together and are subject to moisture. That produces the best conditions with respect to reducing corrosion.

We used nickel-chromium protecting sleeves for thermocouples in furnaces fired with oil with a steam atomizing-burner. The sleeves gave out in very short time, due to the conditions. The oil was high in sulphur content and the conditions were severe. We found that a low-carbon high-chromium iron with a little silicon stood up much better than did the nickel-chromium element. Was there not some particular reducing oxidizing or electrical condition which accounted for the difference?

DR. BIRGER EGEBERG:—Electric-potential differences between adjoining metals are to be expected under any ordinary conditions, and the worst corrosion takes place along the line of contact, as Mr. Trump rightly remarked.

Concerning nickel-chromium steel used as protecting sleeves for thermocouples in oil-fired furnaces, the early failure of such sleeves probably is due to the chemical reaction between nickel and sulphur from the oil, Nickel and sulphur do not go very well together. The high-chromium steel is, however, to be preferred in any case on account of its better non-scaling and heat-resisting properties, compared with ordinary nickel-chromium steels.

I naturally agree with Dr. Foley that, for some purposes, transverse strength is not of such importance as in other cases, which circumstance he has found to be a convenient excuse for a transversely weak steel. Dr. Foley mentions that any steel subjected to a considerable amount of reduction in hot-working is bound to show a great difference in ductility between transverse and longitudinal test-specimens, giving the impression that it is the one-way working of the steel that produces this result. My point was to show that ingots from different heats, when worked alike and one way only into billets and bars, and then tested transversely, may show a wide variation in the ductility figures even in case of equal strength. This difference is caused by conditions inherent in the ingot. In well-made steel, the transverse toughness is about 80 per cent of the corresponding longitudinal figure, but it might go considerably lower in case of nickel and nickel-chromium steels because of their tendency toward transverse weakness. This is my reason for recommending a transverse test of some kind, instead of relying upon the longitudinal test.

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Simultaneous Inspection and Correction of Gears in Production

By CHARLES H. LOGUE[1] AND R. B. FEHR[2]

SEMI-ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS, DRAWINGS AND CHART

BY means of the gear-correcting process described, spur and helical gears are corrected to give a high degree of uniformity in spacing and profile so that the gears become practically interchangeable. They acquire a "crown face" which enables them to run with unusual quietness under practical conditions. This is essentially an inspection-correction process, as it automatically finds and eliminates the errors.

The lap is the important item in the process. It is of chilled cast-iron, gray cast-iron, or type metal, and is made by casting in a mold around a steel chill cut to approximate the gear to be corrected but has a face-width several times that of the gear. The lap, when completed, looks like a wide-faced internal gear.

The gear-correcting machine is of relatively simple construction and performs three main functions: (*a*) it provides reciprocating motion for the gear; (*b*) it causes mutual pressure between the faces of the gear teeth and the lap; (*c*) it advances the gear one tooth with respect to the lap at the completion of every cycle so as to assure uniformity of spacing and contour.

Unlike the many instruments and methods that have been devised for merely detecting errors in gears, the authors state that the so-called inspector-corrector device not only inspects the gears but also corrects them after all other operations, including heat-treating. Further, they assert that the device will do this work without adding to the total cost of gears, for the feeds of gear-cutting machines can be increased to compensate for the time required by the gear-correcting operation. The resultant gears will be interchangeable, and will eliminate virtually all matching-up, as well as rejections in the final tests.

In the discussion, a further description is given of how the conjugate tooth-form of gear and lap is obtained, and additional details of so-called "multiple-series" lapping are presented.

GRADUAL improvement and refinement of a basically sound idea in transportation has been responsible for the evolution of the automobile. Quiet gears constitute one refinement that has been given close attention lately, because of increasing demand for noise elimination. The automobile user has for this reason been educated to demand a car with a quiet rear axle; but this demand was not made until it had been demonstrated that rear axles could be made quiet. He also expects a relatively quiet engine having noiseless or nearly noiseless timing gears, and, because of the difficulties of making timing gears quiet, most automobile builders have adapted chain drive to the timing shaft.

Quietness of the transmission is not expected, probably because everyone has been educated to believe that the production of a relatively quiet transmission is more or less an accidental occurrence. Almost the only requirement insisted upon is that the gears shall not rattle when the car is running in direct or third speed, or when the car is standing at the curb and the engine is idling. In both cases the same four transmission-gears are engaged: the driveshaft pinion with the constant-mesh countershaft-gear, and the countershaft reverse-gear with the reverse idler. We have all been led to expect more or less noise when the transmission gears are transmitting power. All that is expected is reasonable quietness, for the car user always has associated noise with transmission gears. But when it is discovered that relatively quiet transmissions can be produced regularly and not accidentally, as insistent a demand will be made for quieter transmissions as there is at present for quiet rear-axles and engines.

Because of this growing demand for noiseless gears, gear departments have had problems and troubles relating to heat-treating, cutting tools, gear-cutting machines, inspection, the matching-up of sets for assembly and dismantling them after unsatisfactory final tests, and salvaging, all combined with difficulties due to the personal human element. In addition, gear makers discover faults in transmission-gear and gearcase design of such character that a satisfactory job cannot be produced by the best current shop methods. The design and the method of manufacture must both be right. But this is not always the case, and the cost of timing-gear and transmission-gear manufacture has expanded out of all proportion to the results. Additional operations and all kinds of refinement have been adopted. These improvements, accompanied by constant vigilance, have produced better gears; but exceptionally good sets of transmission and timing gears are not yet produced with reasonable consistency.

PRIMARY FACTORS OF QUIET-GEAR DESIGN

Primary considerations for the production of quiet gears are: design, accuracy of spacing, uniformity and accuracy of profile, finish, concentricity, and operating clearance or backlash. The self-alignment of gears is also of fundamental importance.

Design enters into the problem to an extent not ordinarily realized. Proper design increases the allowable errors, automatically reduces the cost of manufacture and tends toward interchangeability. For example, mating gears with insufficient overlap must be held within extremely close limits to assure continuity of

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action and consequently quiet operation; but, with a sufficient degree of overlap, these limits can be extended somewhat. Conventional design, which too often means improper design, is the source of many of the present difficulties, and is really suitable only for ordinary gear-applications as, for example, lathe or milling-machine change-gears.

No other mechanical feature is so important as uniform tooth-spacing. Unequal spacing means a poor and therefore a noisy gear, no matter how accurate the gear may be in all other respects.

Uniform profiles, accurately spaced, result in the uniformity of engagement necessary for quiet operation, because the teeth of a gear are a series of cams for producing constant angular-velocity. It should be remembered that tooth deflection under load may equal or exceed the error in tooth profile. Without this slight flexibility of gear teeth, the production of quiet gears would in some cases be an impossibility.

Accuracy of profile is of vital importance; but, with correct design, accurate spacing, and uniformity of profile, the working limits as to profile accuracy are somewhat widened and this becomes, by comparison, of secondary importance. Experience has demonstrated the impossibility of securing quiet gear-operation by close attention to accuracy of profile alone.

The finish of gear-tooth surfaces becomes increasingly important as the base circle is approached. The smoothness of the profile should increase inversely as the radii of tooth curvature, which become zero at the base circle. For example, in the case of a pinion having a small number of teeth, an almost infinitesimal amount of misplaced material near the base circle will render the gear exceptionally noisy. Such small inaccuracies are difficult to detect and are impossible to remove by current methods. They have an effect on gear operation that is evidently out of all proportion to their magnitude.

Eccentricity in the driving or the driven gear will cause the velocity of the latter to vary according to a sine curve and, as the total variation is distributed over one-half the number of teeth, the tooth-to-tooth error ordinarily is slight, and its effect is not to be compared with errors in spacing and profile of the same magnitude. Excessive eccentricity causes a sound which, gradually rising and falling in intensity, may be objectionable; but the principal objection to eccentricity is the extra backlash that must be allowed to prevent the mating teeth from running tight at one point.

Quiet operation requires, in many cases, minimum operating clearance or backlash, which necessitates accurate spacing, minimum eccentricity, uniformity, and reasonable accuracy of profile.

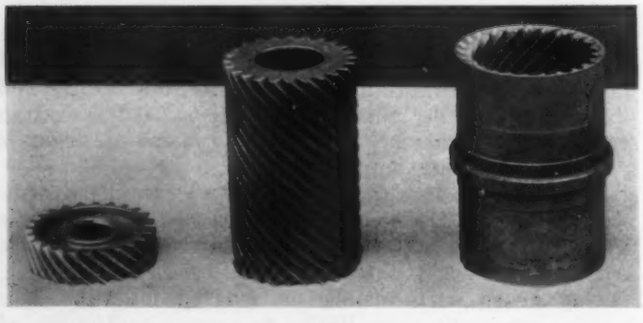


FIG. 1—A GEAR WITH ITS CORRESPONDING CHILL AND LAP AT THE CENTER AND RIGHT

FIG. 2 FIG. 3 FIG. 4

CYCLE OF OPERATION

In Fig. 2, the Gear as It Enters the Lap Is Shown, All Teeth of the Gear Clearing All Teeth of the Lap. After the Application of Torque, the Highest Three Spots of the Gear Are in Contact with the Lap, as Indicated by the Arrows in Fig. 3. The Correcting Operation Is Complete in Fig. 4, All Teeth of the Gear Making Full Contact with All Teeth of the Lap

CROWNED FACES DESIRABLE

Suppose that all the conditions outlined as essential to quiet operation have been fulfilled and that the mating gears will revolve with a backlash of say 0.0005 in. Is there any assurance that they will operate quietly? If such a pair of gears is correctly aligned, and the housing or casing as well as the shafts are sufficiently rigid to maintain this correct alignment, it is reasonable to assume that the pair will operate satisfactorily. Actually, however, the alignment cannot be perfect, nor can any alignment, perfect or imperfect, be maintained under all conditions of load, because of shaft deflections, variable conditions of sliding gears on splined shafts, and the like. Either the shafts must hold the gears in proper alignment or the gears will attempt to align the shafts and be noisy.

It is doubtful if the spiral-bevel gears in the rear axle could have attained their present quietness with a full-face contact such as has been attempted for transmission and timing gears. In spiral-bevel gears the driving and the driven faces have slightly different curvatures, which result in a full-profile bearing only in the central portion of the tooth face and taper off toward each end of the face, the effect being known as a "crowned face." In the spiral-bevel gear the position of the full-profile-bearing contact will vary with each change in the alignment of the shafts. No cramping can occur unless the change in alignment is greater than that provided for by the difference in the face curvatures. It is thus evident that the crowned face of spiral-bevel gears has been an exceedingly important factor in their quiet operation. Since perfection of gear alignment is beyond the range of practical possibility, it seems obvious that a slightly crowned face is essential to the quiet operation of all gears and is, therefore, just as important in timing gears and transmission gears as in rear-axle gears.

DESCRIPTION OF THE PROCESS

The essentials for carrying out the Copland gear-correcting process consist of a lap, a gear-correcting machine, and a continuous flow of abrasive through the lap, which is of chilled cast-iron, gray cast-iron, or type metal.

The lap, shown at the right in Fig. 1, is made by casting in a mold around the steel chill shown in the central view, which is cut approximately to the dimen-

sions of the gear to be corrected except that it has a 6-in. face. The chill is removed from the casting by hydraulic or mechanical means, and it can be used repeatedly. No special effort is made to obtain great accuracy in the making of the lap, as it will automatically be trued-up in from 10 to 30 min. during the normal operation of the machine, and will assume the average form of the gears that are put through it.

The gear-correcting machine is relatively simple in construction and performs three main functions. First, it provides a reciprocating motion for either spur or helical gears with respect to the lap, which is suitably fixed on the machine; second, it provides for mutual pressure between the faces of the gear teeth and the lap by the application of torque as soon as the gear has entered the lap. The torque provides not only pressure for rapid abrasion but a positive means for correcting errors in spacing, for, as soon as a new gear enters the lap, the highest three spots on the tooth faces will come into contact with the teeth of the lap, since the gear on its arbor is free to find its own center. Not only will the errors be corrected in a positive way, but the wear of the lap will be automatically compensated.

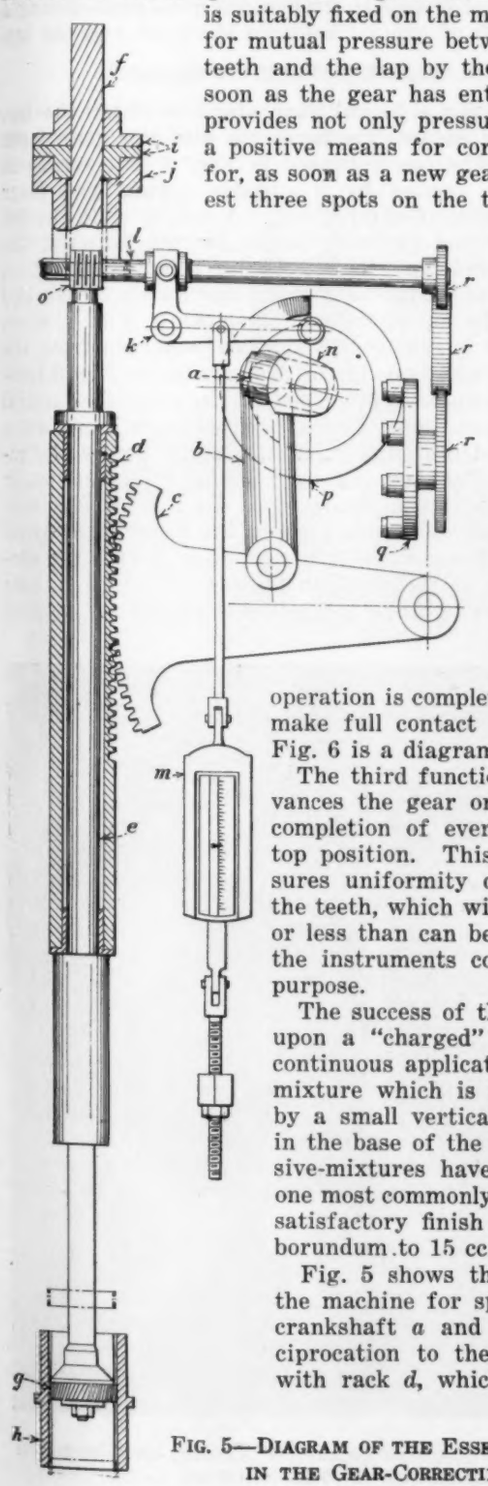


FIG. 5—DIAGRAM OF THE ESSENTIAL MECHANISMS IN THE GEAR-CORRECTING MACHINE

Fig. 2 shows the gear as it enters the lap. All teeth of the gear clear all teeth of the lap. In Fig. 3, after the application of torque, the highest three spots on the gear are in contact with the lap. In Fig. 4 the correcting operation is complete and all teeth of the gear make full contact with all teeth of the lap. Fig. 6 is a diagram of the cycle of operation.

The third function is that the machine advances the gear one tooth in the lap at the completion of every cycle, that is, at every top position. This feature automatically assures uniformity of contour and spacing of the teeth, which will be well within 0.0002 in., or less than can be measured accurately with the instruments commonly employed for the purpose.

The success of the process does not depend upon a "charged" lap, but rather upon the continuous application of a suitable abrasive-mixture which is circulated through the lap by a small vertical centrifugal pump located in the base of the machine. Numerous abrasive-mixtures have been found effective, the one most commonly used and which produces a satisfactory finish being 10 cc. of FFF carborundum to 15 cc. of kerosene.

Fig. 5 shows the essential mechanisms of the machine for spur and helical gears. The crankshaft *a* and connecting-rod *b* give reciprocation to the rack segment *c* meshing with rack *d*, which carries the spindle *e* up and down. The helical guide *f* has the same lead as the gear *g* to be corrected and the lap *h*. The helical guide *f* moves through split nut *i*, which is mounted on worm-wheel hub *j*.

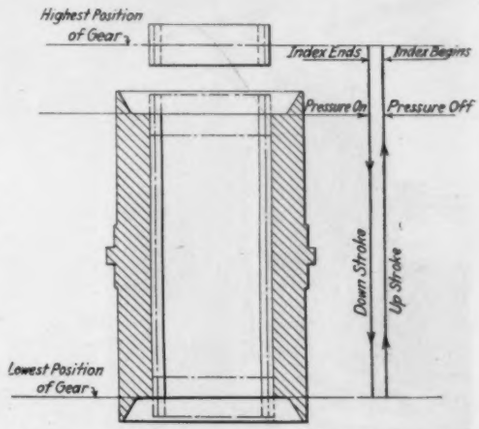


FIG. 6—DIAGRAM OF THE GEAR-CORRECTING CYCLE

Bell-crank lever *k* is connected to worm shaft *l*. Spring scale *m* pulls downward on the arm of lever *k*. Pressure-control cam *n* prevents the arm of lever *k* from falling when gear *g* is leaving the lap to be advanced or "indexed" one tooth and returned to the lap *h*. But as soon as gear *g* has safely entered lap *h*, pressure-control cam *n* moves past the roller at the end of lever *k*, which is then free to move under tension of the spring scale *m*. This moves in an axial direction worm *o*, which, acting as a rack, gives a partial rotation to worm wheel *j* and therefore to gear *g*, until the teeth of gear *g* press against the teeth of lap *h*. The gear *g* goes to the bottom of lap *h* and returns to the top, when pressure-control cam *n* lifts lever *k* and moves the teeth of gear *g* away from the top teeth of lap *h*.

When gear *g* is clear of lap *h*, index cam *p* gives partial rotation to pin-wheel *q*, which gives rotation to index gear-train *r* and indexes gear *g* one tooth. After indexing, gear *g* moves toward and enters lap *h*, and the cycle is repeated until an automatic mechanism stops the machine with the gear at the top of the stroke ready for the operator to take out the arbor holding gear *g* and put in another arbor. The only work the operator does is that of loading, changing, and unloading arbors.

The accuracy of the results, as regards uniformity of spacing and contour of the gear teeth, does not depend upon the accuracy of the so-called "indexing" mechanism, which serves merely to advance the gear one tooth at a time with respect to the lap. This mechanism

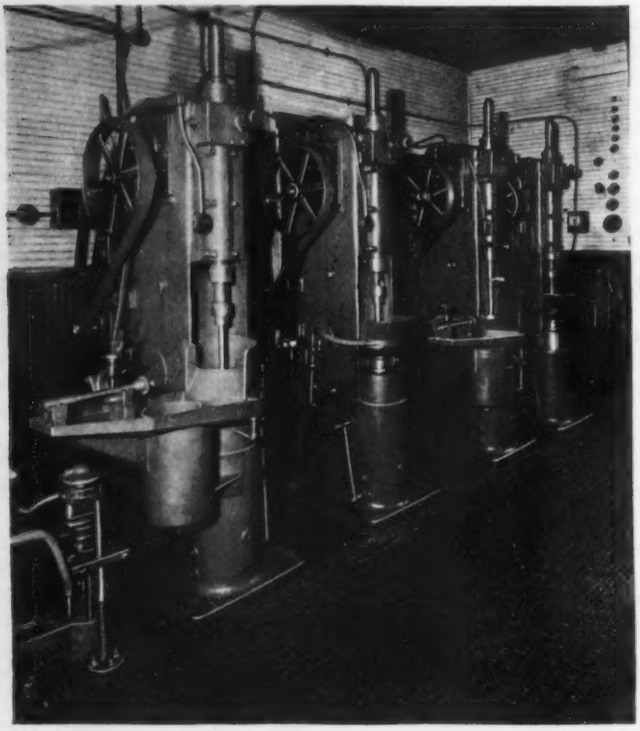


FIG. 7—A BATTERY OF GEAR-CORRECTING MACHINES

needs only to be accurate enough to cause the gear to enter the lap, there being an initial clearance of several thousandths of an inch between the gear and the lap. The accuracy of the process depends upon the "averaging" effect produced by each new application of torque, which occurs as soon as the gear teeth register with a new set of lap teeth. The more times this cycle is repeated, the more accurate will be the results up to the point when all the errors are eliminated; that is, when all the teeth have been "cleaned up" as shown by visual inspection.

Fig. 7 shows a battery of four gear-correcting machines that can be run by one or two operators, depending upon the footage required to correct the gears. Each machine is driven by a 1½-hp. motor mounted on the rear of the frame, the maximum load being in general less than 1 hp. Each machine, or one machine in a battery of machines, is provided with a locating fixture such as is shown in Fig. 8. This enables the operator to place each gear on the arbor in the same angular relation with the drive pin of the arbor, so that there will be no difficulty in having the gear enter the lap when starting the machine. The lap is mounted in its holder on the machine in such way that it can be adjusted or removed easily.

A gear is set on its arbor by means of the locating fixture shown in Fig. 8, the arbor being then placed and held in position on the vertical spindle of the machine by the chuck, which is also shown. The starting lever is then lifted and a friction clutch puts the spindle into operation at 120 double strokes per min., each giving a total of 1 ft. of contact between the gear and the lap.

HOW "CROWNED FACE" IS OBTAINED

Fig. 9 shows a helical gear about to enter the lap. As the gear enters, the lap teeth and the gear teeth clear each other as indicated in Fig. 2, but torque is immediately applied by a suitable spring and lever mechanism controlled by a cam. A spring scale enables a predetermined pressure to be exerted between the gear teeth and lap. This pressure usually is kept on until the gear completes a down and an up stroke and returns to the top of the lap, as shown in Fig. 6, when the pressure is removed as the gear emerges from the lap to be advanced one tooth. The arrows in Fig. 3 indicate how the highest three spots on the gear make initial contact with the lap. These high spots are found automatically and are eliminated simultaneously by the reciprocation of the gear through the lap, which action, in conjunction with the advancing of the gear one tooth at each top position, reduces these inaccuracies until all faces of all the gear teeth are in contact with the conjugate faces of the teeth in the lap. This two-stroke cycle is repeated until the required footage of lapping

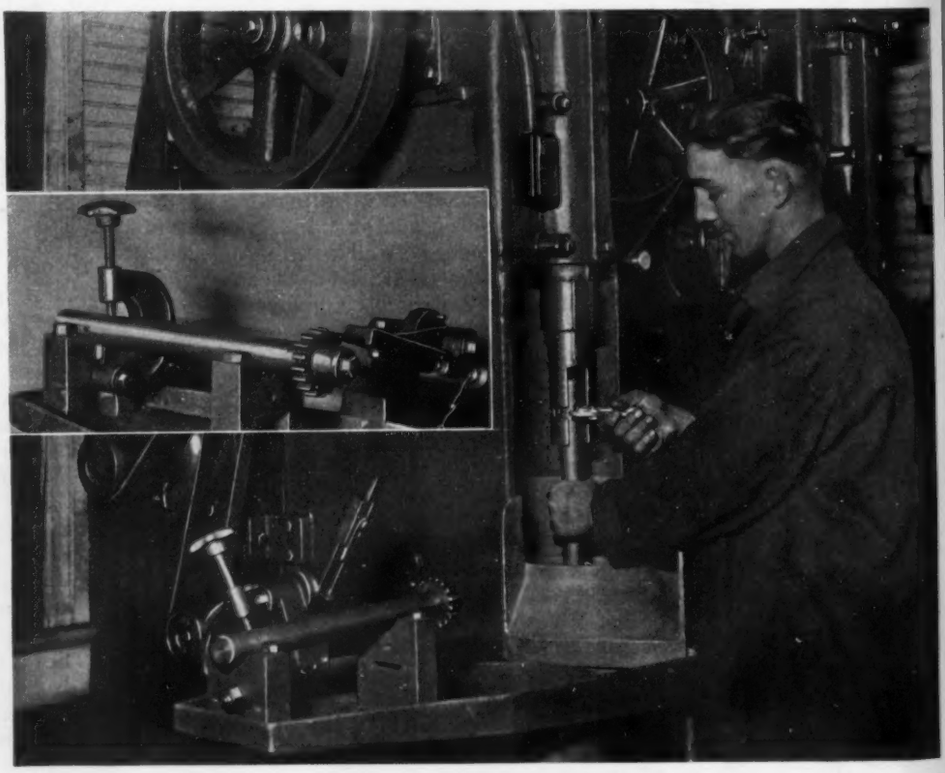


FIG. 8—TWO VIEWS OF THE FIXTURE FOR LOCATING GEARS ON ARBORS, AND OPERATOR PLACING AN ARBOR IN THE CHUCK ON THE MACHINE

has been run, the machine being then stopped automatically with the gear in the top position for removal of the arbor from the chuck.

It is evident that a "crowned face" is obtained by keeping the full pressure on while the gear is partly out of the lap at the top and the bottom, thus giving a higher unit-pressure at each end of the teeth. The amount of "crowning" obtained after 200 ft. of gear correcting, which is the maximum amount usually required per side, is 0.0010 to 0.0015 in., as determined by half the difference in thickness of the tooth between the middle and edges.

Principal Features Summarized

From the foregoing description it is evident that the process is essentially an inspection-correction operation, for it automatically locates errors and irregularities

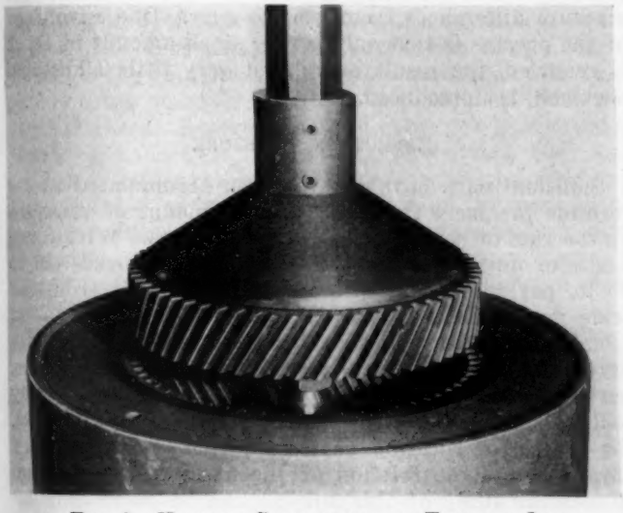


Fig. 9—Helical Gear about to Enter a Lap

and eliminates them. Errors in spacing can be reduced within the error of available measuring instruments, or to practical perfection, which is an important feature. Uniformity of profile from tooth to tooth and from gear to gear is assured, and the actual profile obtained will be the average of the profiles which the gears had before being put through the process. If this average profile should not be within the required limits, it is possible to alter it by a relatively simple means, but this procedure has been found necessary in only a few instances.

A high degree of concentricity can be obtained by correcting the gears *before* finish-grinding the hole. A special chuck locating from the accurately spaced and uniform faces of the teeth will then enable the hole to be ground with minimum eccentricity. In general, however, when the desired degree of concentricity can be obtained by the usual methods, the gear-correcting operation is performed *after* the finish-grinding of the hole. A uniformly smooth surface is secured on all teeth, initial irregularities too slight to be measured are automatically eliminated, and the process is as easily applied to hardened gears as to soft-steel or cast-iron gears of either spur or helical type.

Not only are uniformity and interchangeability assured, with consequent elimination of the selective assembly of gear sets, but the important "crowned face" that will enable the gears to be self-aligning is obtained

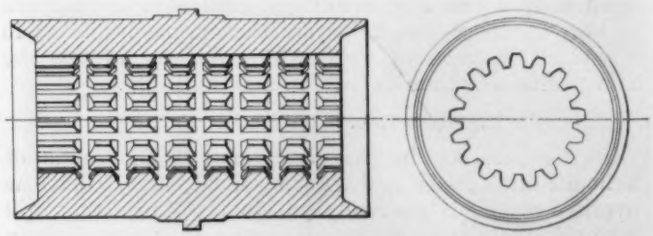


Fig. 10—A Lap Modified to Cause a Gradually Increasing Amount of Abrasion from Root to Tip of Teeth

readily, self-alignment being a property that gives good gears a chance to run quietly. These results are obtained with small effort and expense. For example, the operator's time on each gear is only 1 to 2 min., and this time can be compensated by increasing the feed of the gear-cutting machines. It is expected that the immediate results of employing this process in a gear-making department will be to produce uniformly better and quieter gears, to reduce the total of all costs properly charged to gears, and to eliminate uncertainty in the making of good gears.

Process as Applied to Quantity Production

Regarding the practicability of the process in quantity production, one of the questions raised by those who learn of it for the first time refers to the lap, or "master tool" as it has been called. It is not always understood at first that this master tool is a result of the inherent accuracy of the process and does not involve any great difficulty in its making. When the lap is first placed in position on the gear-correcting machine, it is a relatively crude tool. Gears from the regular run, to the number of 20 or 30, are then put through the process, but with only about 25 ft. of lapping for each gear instead of the usual 100 to 200 ft. per side. The result of this operation, which requires from 10 to 30 min., is that the lap gradually assumes the average contour of the gears and each individual gear is but slightly affected. As soon as the high spots of the lap have been removed and the gear teeth show evidences of being touched all over, the lap can be considered ready for regular production. The same gears that were used for putting the lap into condition can now be put through it again, giving to each the footage of lapping required to clean up all the teeth.

The important element, the lap, is improved with use; the more gears that are put through it, the more accurate the lap becomes, until it reaches the practical limit of accuracy, which is then maintained throughout its life. The inherent nature of the process makes it unnecessary to sharpen or dress the lap or otherwise to

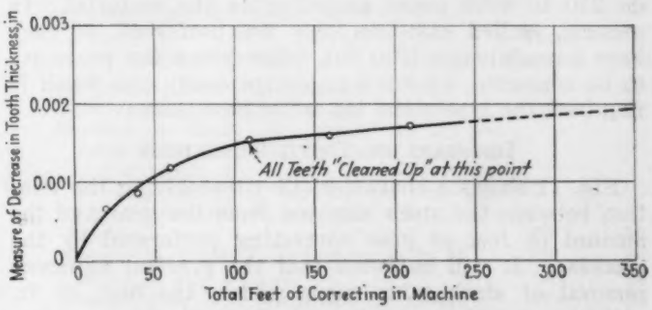


Fig. 11—Curve Showing Decrease in Tooth Thickness

keep it in a trued-up condition. All that is required is that the gears be cut within the normal limits as to size and accuracy of profile. Uniformity of spacing and profile are then cared for automatically.

Modification of Tooth Form

Our experience in the correcting of thousands of helical timing-gears and transmission gears is that the average profile is generally within the limits that will give relatively quiet gears. However, instances exist in which it may be desired to modify the resultant tooth-form. Suppose a group of gears to have a positive tooth-form such that the profile near the tip of the tooth is one or more thousandths of an inch thicker than the involute and that it is desired to bring this profile down to a form more nearly approaching the involute. The group of gears will be put through what we term the "multiple-series" process. All the gears will be put through, say for 50 ft. of lapping on each side. They will then be put through again for 50 ft. of lapping on each side, and yet again, if more footage is required to clean up all the teeth.

We will then have a group of gears in which the profiles are so nearly alike that their differences cannot be measured accurately by any means of which we know, but these profiles are all in error to the same degree, say 0.002 in. They are then put through a modified lap such as is shown in Fig. 10, in which the tips of the teeth will undergo more abrasion than the roots of the teeth, and the tooth profiles will be brought down within any desired limits. If the average profile of the raw gears is determined by careful measurements, it is possible to correct it by putting the gears through the modified lap in the first place and thus to minimize the amount of stock that is removed. This resort to the modified lap is not practised except in special cases, and it has been our experience that the average profile of large lots of gears can, by proper attention, be maintained within required limits on the gear-cutting machines.

Life of Laps

Based on actual data obtained, the life of laps for gears of 7 to 10 diametral pitch can be expressed in terms of the total footage. For hard and semi-hard cast-iron laps the life is 300,000 to 600,000 ft.; for soft cast-iron laps, 150,000 to 200,000 ft.; and for type-metal laps, 25,000 to 35,000 ft.

Some gears require 200 ft. of lapping on each side of the teeth, or a total of 400 ft. Other gears, such as crankshaft timing-gears, may require 100 ft. or less on one side only. It is thus seen that the life of a lap depends on the footage required to finish a gear. In the case of the crankshaft gears referred to, a lap may do 250 to 6000 gears according to the material. In general, chilled cast-iron laps are preferred, as they have a much longer life; but, when only a few gears are to be corrected, or when an exceptionally fine finish is required, the type-metal lap is the best choice.

Decrease in Tooth Thickness

Fig. 11 shows a characteristic curve giving the relation between the stock removed from the gear and the amount in feet of gear correcting performed by the machine. It will be noted that the greatest apparent removal of stock takes place within the first 40 ft. of gear correcting, the decrease in tooth thickness being about 67 per cent of that at 100 ft.; and that, beyond 100 ft., the curve becomes practically a straight line with only a gradual slope. The reason for this is that only the irregularities and high spots of the gear are touched at first, and therefore the unit pressure is much higher than that later on. This measure of the decrease in tooth thickness was determined by placing two gears in metal-to-metal contact on a gear-testing stand and noting the readings of the dial indicator. In general, it can be stated that the decrease in tooth thickness will be 0.001 to 0.003 in., depending upon the amount of correction necessary to bring the gear within the required limits of size and operating characteristics. However, for a given setting of the automatic stop on the gear-correcting machine, say at 100 ft., the decrease in tooth thickness, and therefore the amount of stock removed from all gears put through the process, is so nearly uniform that it is difficult to measure differences from gear to gear. One advantage of the process is that only a very small amount of stock is removed, the result being that very little additional backlash is introduced.

Effect of Pressure

Sufficient data have not yet been accumulated to determine precisely the effect of the amount of pressure on the rate of removal of stock from gears. Within the limits of unit pressure that have been employed—10 to 25 lb. per sq. in. of tooth face as calculated from the scale pressure, lever system, and tooth dimensions—it seems that the rate of abrasion is by no means directly proportional to the calculated unit-pressure but varies, perhaps, as the square root of the unit pressure. Many factors are involved, such as the speed of the machine, the inertia of rotating parts, the kind and amount of abrasive, and the friction of the pressure mechanism. A detailed study of this subject can be made only by prolonged investigation. Practically, it has been found that the pressure should be increased to the point above which there may be a tendency to scratch or score the tooth surfaces, and should then be maintained slightly below this point. Fortunately, within rather wide limits of unit pressure, there is no great difference in the results obtained as to quality of product and rate of abrasion, which seem to depend more upon the footage than upon any other single factor.

The process should be regarded as a "precisioning" or final finishing-process in which minute irregularities and inaccuracies, which are inevitable in the most carefully cut gears, can be removed rapidly and automatically. The gear-cutting machines are expected to do the real cutting, and it is believed that their feeds can, in general, be increased substantially without increasing errors in the gears too much for them to be removed economically by the inspector-corrector machine described.

Application to Helical Gears

Our experience in the finishing of thousands of helical gears indicates what can be expected in large-scale production. These gears were corrected in lots ranging from 50 to 400 gears of each kind. The camshaft gear was run for 100 ft. of lapping on each side of the teeth, since it was both a driving and a driven gear. With the gear-correcting machine operating at the rate of 120 ft. per min., the operator's time was about 2 min. in the case of the camshaft gear, and about 1 min. in the case

of the crankshaft and the accessory gears, which were run for 100 ft. of lapping on one side only. In large-scale production this time could be cut in half, as the same operator easily could run two machines and thereby double his output.

Fig. 12 shows the fixture that has been used for testing assembled timing-gear trains. It was originally called an inspection fixture, but it was found that almost all these gears were interchangeable and could be assembled without prior inspection, except as to appearance. Therefore the fixture is more properly called an assembly test-fixture. It is belt-driven from a 1-hp. motor and has a small hand-brake by which the operator can apply a load to check whether, at certain speeds, the gears are within the established limits of quietness. The use of a battery of gear-correcting machines in conjunction with a simple assembly test-fixture unquestionably will result in a remarkable uniformity of product, the virtual elimination of engine tear-downs, and a general economy in the production of quiet gears.

From the data obtained, the indications are that spur gears offer no problems that have not been met with helical gears. Several thousand gears for transmissions have been corrected so satisfactorily that they have passed final assembly-tests under conditions which can be regarded as strongly indicative of the possibilities of the process. Fig. 13 shows a gear-testing stand adapted for the comparative testing of spur gears. A small motor is used to spin the gears, which are placed on studs at the correct center-distance. This simple device has been very effective and is of real value in enabling us to compare gears before and after correcting.

Machine Arrangement for Large-Scale Production

If only 100 ft. of lapping is required per gear, and on one side only, the following scheme will be found to produce the desired quality of gears economically. Two machines will be operated by one man, four arbors being in use when two different gears are being finished, or three arbors when one kind of gear is being finished in both machines. In the case of two different gears and four arbors, the time schedule is as follows, A, with its subscript number, representing the particular arbor and M, with its subscript, the machine:

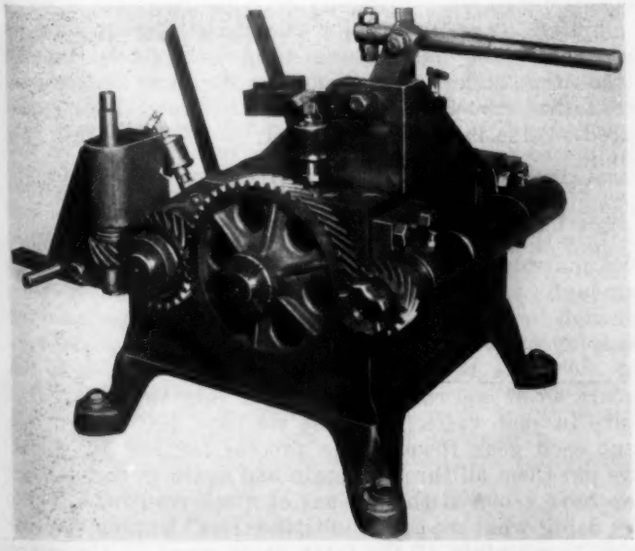


Fig. 12—An Assembly Test-Fixture for Helical Timing-Gears

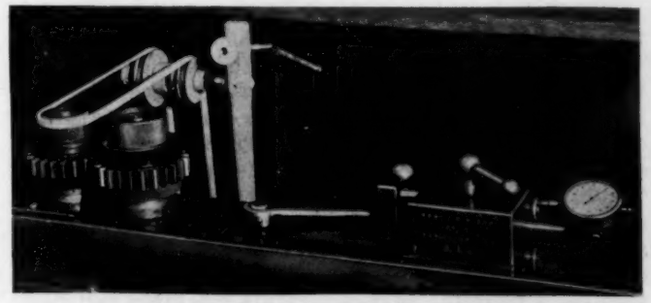


Fig. 13—Device for Making Running Tests of Spur Gears

Cycle of operator's work	Time, Sec. Elapsed	Total
Remove A_1; place A_3 in M_1	10	10
Unload and reload A_1	12	22
Remove A_2; place A_4 in M_2	10	32
Unload and reload A_2	12	44
Inspect gear and machines, or rest; meanwhile, M_1 has been operating 50 sec., has lapped 100 ft. and has finished a gear	16	60
Remove A_3; place A_1 in M_1	10	70
Unload and reload A_3; meanwhile, M_2 has been operating 50 sec. and has finished a gear	12	82
Remove A_4; place A_2 in M_2	10	92
Unload and reload A_4	12	104
Inspect gear and machines, or rest	16	120
Repeat the cycle		

It will be noted from the foregoing schedule, which is based on time studies of the actual operations, that 120 sec. is required to complete the cycle and that four gears are finished, or one every 30 sec. With due allowance for contingencies, it is reasonable to expect that one operator with two machines could correct 80 gears per hr., if 100 ft. of lapping is required per gear. Once the process has been properly started under competent supervision, the direct-labor cost will be extremely low.

If the other extreme of 200 ft. of correcting on each side is considered, or a total of 400 ft. per gear, it will be found advantageous in some cases to use one operator with four machines and six arbors. Two of the machines will operate on one side of the gear teeth and the other two will operate on the other side, 100 ft. per machine. Three of the arbors are arranged to hold the gear with the hub up; the remaining three hold the gear with the hub down. Each lap will thus assume the average profile of both sides of the teeth, and any lack of symmetry of the two profiles will thus be corrected. The time schedule is as follows:

Cycle of operator's work	Time, Sec. Elapsed	Total
Remove A_4 from M_1; place A_5 in M_1	10	10
Remove A_2 from M_2; place A_4 in M_2	10	20
Remove A_2 from M_3; place A_3 in M_3; meanwhile A_1, with its gear, has been put through M_1, M_2, M_3 and M_4, representing 100 ft. of lapping on each machine and 200 ft. on each side of the teeth	10	30
Remove A_1 from M_1 and place A_2 in M_4	10	40
Unload A_1 and load A_6	14	54
Inspect gear and machines, or rest	10	64
Repeat the cycle		

It will be noted that 64 sec. is required to complete the cycle and that one gear is finished during this time. Under these conditions, it is fair to expect that, in actual practice, one operator with four machines could average 30 gears per hr. Other arrangements and schedules will suggest themselves when a study has been made of the special conditions of any particular job. The important things to remember are that uniformity of spacing and profile with a crowned face will result automatically, but that the accuracy of the profile will depend upon the *average* of the profiles of the gears as they come from the gear-generating machines and heat-treatment. It is therefore important that the gears be cut so as to have the general profile within reasonable limits of accuracy.

The process also can be used to salvage gears. Nearly all the gears thus far corrected have been rejected gears. The facts that such gears have been salvaged and put through final assembly and test with a negligible number of rejections, and that they have in numerous instances been used to replace gears that had been rejected in final road-tests, are strongly indicative of the efficiency of the process in correcting gears positively. But the real field for the process is in large-scale production.

The process does not depend for its savings in production costs upon the substitution of a less expensive material for gears. For example, while it is possible to produce by the process a quiet train of relatively inexpensive all-metal timing-gears, it is also possible to reduce the cost of a train in which there is one composition gear by applying the process to the metal gears, thus reducing the total cost of production and at the same time eliminating the errors usually found in such gears. With gears having uniformity of spacing and profile it is reasonable to expect greater durability and, therefore, a longer life with quiet operation. The use of the process assures the minimum removal of stock, and consequently the minimum amount of backlash between mating gears.

THE DISCUSSION

F. G. WHITTINGTON[3]:—Of what metal is the lap constructed?

R. B. FEHR:—When correcting a large number of gears, we make the lap of chilled cast-iron by not preheating the chill before pouring. When it is an experimental job in which we may have to modify the contour, the lap is made of soft cast-iron so that we can easily use a cutting tool, without resorting to a grinding operation, for modifying the lap. When only a few gears are to be corrected or a particularly high polish is desired, we use type-metal, which has the added advantage that the metal can be poured easily in the laboratory.

CHAIRMAN D. D. ORMSBY[4]:—How is the conjugate tooth-form of gear and lap obtained?

MR. FEHR:—The wide gear or "chill" shown at the center in Fig. 1 is just like the gear that is to be corrected. It is cut by the ordinary methods with the teeth a trifle thicker than those on the gear, so that, when the gear enters the lap, there will be a slight clearance of say 0.005 to 0.006 in. As to how we maintain a proper gear-contour with a condition of this sort, the lap referred to is the counterpart of the external gear because it is cast around the chill, which is practically the same as the external gear that is to be corrected. Therefore, when the gears to be corrected enter the lap and emerge, this action at first takes off merely the high spots of both gear and lap, and thus the lap, which looks like an internal gear, is gradually brought to a form identical with the average contour of the gears going through. The pressure that I referred to previously comes on at every stroke and, as the lap wears down, this application of pressure compensates for the wear.

MR. WHITTINGTON:—What is the proportion of the length of lap to the face of the gear? In other words, for a gear of a certain width, what would be the length of the lap?

MR. FEHR:—There must be a clearance of 1½ in. at the top of the 7½-in. stroke for all the laps that we make, so that, with the exception of shorter laps for very small gears, the length of lap is usually 6 in. for timing and transmission gears.

ACCURACY OF TOOTH SPACING

A MEMBER:—I shall not presume to say that absolute spacing actually exists. Someone has said that all dimensions are myths, and that the only question is how nearly we can approximate them. How near, in actual measurements, does the operation produce "absolute spacing"?

In dealing with case-hardened gears, I have found that there is in some cases a necessity for an allowance of something like 0.010 to 0.012 in. to allow for hardening distortion so that the teeth will clean up and give a correct contour. How does Mr. Fehr deal with such conditions?

MR. FEHR:—Our device for measuring spacing is claimed by the makers to be accurate to 0.0001 in. We think that under usual conditions it can be relied upon to within 0.0002 in. The gears that have been measured on this instrument certainly come well within this limit.

The process is not a gear-cutting but rather a gear-correcting process. The gears are expected to come within the limits of size that are customary, and we do not make any claim for removing economically a large amount of stock; but stock can be removed if time enough is taken to do it. The means that we have for keeping uniform contours when removing large amounts of stock are relatively simple. We do not finish the gears all at one time, this being a very important feature in such cases. Suppose we have 100 gears. We put each gear through the process for 100 ft. Then we put them all through again and again in series until we have removed the amount of stock required. Thus, by doing what we call "multiple-series" lapping, we are able to maintain all the tooth contours of all the gears within very close limits of the average contour of the gears we put in. If we kept one gear going through

[3] M.S.A.E.—Chief engineer, Stewart-Warner Speedometer Corp., Chicago.

[4] M.S.A.E.—Consulting sales engineer, Brown-Lipe-Chapin Co., Syracuse, N. Y.

until completed, there might be a slight tendency for the contours to become either more positive or more negative, especially if the lap or gear happened to be of somewhat variable hardness from tip to root of tooth. But, so long as we keep putting the gears through in multiple-series, never doing more than 100 or 200 ft. on one gear at a time, we find that uniform contours can be maintained. The fact is, however, that we hardly ever require more than a total of 200 ft. on one side of an average gear to clean it up; that is, to correct spacing and to produce uniform contours.

C. L. KNOPF*:—If the lap is in continued use, does it not develop shoulders and is it not necessary to shorten the stroke to avoid excessive crowning of the face of the gear teeth?

MR. FEHR:—Referring to Fig. 6, the gear is brought out half way from the lap at the bottom; at the top it comes out with the pressure still on; so the tendency is to bell-mouth the lap rather than to create any shoulder. That is how the "crowned-face" effect is obtained.

CHAIRMAN ORMSBY:—What is the length of life of such a lap?

MR. FEHR:—The chilled cast-iron lap has a life of from 1000 to 3000 gears, if both sides of the gear are put through the process.

A MEMBER:—Is this process considered practicable for case-hardened gears of from 85 to 90 Shore hardness?

MR. FEHR:—Case-hardened gears of as high as 85 Shore hardness have been corrected. We have not yet found any gear of any degree of hardness that would not yield readily to the correcting effect of the process.

MR. WHITTINGTON:—Concerning the pressure on the gear when going through the lap, is the lap held rigidly against the gear?

MR. FEHR:—The lap is held in a fixed position on the machine, but the gear on the free end of its arbor is allowed to float to its proper position in the lap when the torque is applied by spring tension.

*M.S.A.E.—Lubrication engineer, Sinclair Refining Co., New York City.

Motor-Truck and Railroad Fields

MOTOR-TRUCK service appeals to shippers who value the elements of direct collection and delivery, speed and flexibility, savings in containers, and the lessening of risk of damage and theft of fragile, perishable or high-value commodities. These advantages may outweigh the desirability of the lower rate by rail. But where such advantages are slight and the distance is such as to enable the railroad to serve at lower cost, the shipper is likely to favor the railroad if its service is reasonably adequate. Railroad service, moreover, partly because of motor-truck competition, is constantly improving, and the potency of the motor-truck appeal is thereby correspondingly lessened.

Note should be made of the fact that truck rates per ton-mile cannot be tapered with distance in the same degree as can railroad rates. Truck rates, because the element of terminal cost is relatively light, tend to vary substantially in direct proportion to the distance the shipment is moved, while in railroad rates the terminal cost is such a substantial part of the whole that the rate per ton-mile diminishes rapidly as the distance increases. The competitive strength of the motor-truck, therefore, is greatest in the zone of short hauls and grows less as the haul is lengthened.

It is easy to see why the trucks cannot successfully compete with railroads for mass movements of freight outside of terminal districts. The average freight-train in 1926 carried 772 tons of freight. To carry that train-load in motor-trucks of 5-ton capacity, fully loaded, would require 154 trucks and at least 154 truck drivers. The freight train normally has a crew of five to six men. For each man on the freight train there were 128 to 154 tons; for each truck driver there would be but 5 tons. The fuel consumed by the freight train was about 300 lb. per train-mile and the cost at $4 per ton was 60 cents. For the 154 trucks, the total gasoline consumption would be at least 40 gal. per mile, and the cost at 18 cents per gal. would be $7.20. If the fleet of trucks were spaced a truck length apart they would occupy more than one mile of highway.

This comparison, impressive as it is, does not entirely reflect the facts, as the average train-load just given is for trains in both directions—heavy traffic and light traffic—while for truck operation a full load is assumed for each truck. In the heavy-traffic direction alone the average freight-train has at least 1200 tons of freight. That load would require the use of 240 5-ton trucks and the same number of truck drivers.

If we assume that the average truck-load is 80 per cent of the capacity of the truck and that its loaded mileage is 67 per cent of its total mileage, and further that its average speed inclusive of road delays is 15 m.p.h., the average 5-ton truck produces 40 ton-miles per truck-hour. On these assumptions, the ton-mile production in the average train-hour is equivalent to the ton-mile production in 230 hours of the average 5-ton truck.

Only in the cases of light way-freights or branch-line trains with a half dozen cars or less can the motor-truck approach anywhere near economic equality. And it is in such cases that the railroads are finding it advantageous to use the motor-trucks themselves.

The bulk of freight traffic in this Country is in mass movements over long distances. In that field the railroad is economically supreme. There is business enough for both forms of transportation. Notwithstanding the spectacular development in the use of motor-trucks and the freight tonnage they handle, the volume of railroad-carried tonnage has been increasing steadily and is likely to increase further, and railroad capacity, both in equipment, terminal, and line, is likely to be effectively utilized. A depression which may react unfavorably upon transportation demand is no more likely to bear heavily upon railroads than upon motor-truck operators. The question is not the survival of one and the downfall of the other; it is a problem of finding the desirable economic balance, a fairly definite limitation of field with wise coordination, so that in the two fields each agency of transportation may function with maximum economic efficiency.—From report of Commission on Commerce and Marine, of the American Bankers Association.

Motor-Oil Characteristics

Discussion of Wilkin, Oak and Barnard Annual Meeting Paper[1]

RESULTS of an experimental study of the viscosity characteristics of motor oils at low temperatures and their influence upon cranking torque and circulation within the engine are presented by the authors.

At temperatures in the neighborhood of 0 deg. fahr., even oils of asphaltic origin appear to possess some plastic characteristics, while those of the mixed and paraffin-base types deviate widely from the generally accepted laws of viscous flow. Oils of these latter classes have apparent viscosities which tend to increase with decreasing shearing-stress and to become somewhat greater than might be expected from a study of their characteristics at normal temperatures. However, as resistance to cranking the engine is due mainly to oil in thin films on the cylinder walls, the relatively small temperature-viscosity coefficient of the wax-bearing oils gives them a marked advantage over those of asphaltic origin, an advantage which becomes greater as the temperature is lowered.

Circulation tests in an engine equipped with a comparatively small-mesh screen over the pump intake indicated that circulation was not obtained until the oil in the sump attained its "pour-point" temperature. In general, the work indicates that a low-temperature viscosity coefficient is highly desirable to minimize cranking effort, and that free circulation requires an oil the effective viscosity of which does not increase too rapidly at very low shearing-stresses.

The discussion includes statements that many of the experiments described in the paper have been duplicated by other experimenters and that the results confirmed those obtained by Mr. Wilkin. Another discusser comments upon the results of experiments he made in the course of an investigation conducted at the Bureau of Standards relating to the problem of the lubrication of an aviation engine during the starting and warming-up periods. The need for a cold-test oil is emphasized, and a device for measuring oil-film shear-resistance is described. Tests using electrical means of measuring breakaway torque are cited, a process for dewaxing paraffin-base oils is outlined, and comparative results of tests of an asphaltic-base and of a paraffin-base oil are shown in charts.

H. C. MOUGEY[2]:—The paper clears up a number of mysteries. We have had the opportunity of following this work while it was being carried on, and we have duplicated many of Mr. Wilkin's experiments and obtained parallel results. He shows the importance of low viscosity at starting temperatures and of low pour-test, also bringing out clearly the fact that these two properties are entirely different in their effects. In other words, it appears that a large percentage of the commercial lubricating oils can be divided into two main classes: first, oils with which engines can be cranked at low temperatures but which do not circulate after the engine has started until the oil has been warmed up to a temperature equal to or above its pour-point; second, oils with which engines cannot be cranked at low temperatures but which would circulate if the engine could be started. A third, or desirable, class includes oils with which engines can be cranked at low temperatures and the oil will also circulate at low temperatures. This is clearly a problem that belongs to the oil industry.

Another solution of the problem would be for engines to be designed so that they will not require oils of high viscosity under operating conditions; consequently, if lighter oils are used for normal operation, they will not become abnormally thick at low temperatures. Stated in other words, both the automotive and the oil industries are confronted with the problem of decreasing the over-all effect of changes of viscosity with temperature. If the oil industry can decrease the rate of change of viscosity with temperature, it has made an improvement; if the automotive industry can decrease the total change in oil temperatures, it also has made an improvement. Since it is impossible, under ordinary conditions, to limit the lower end of this temperature range, the only place where this improvement can be made by the automotive industry is at the upper end.

OIL-COOLERS FOR INCREASING WINTER VISCOSITY

Oil-coolers are sometimes considered as devices to increase the viscosity of oils in summer, and their importance in winter operation is underestimated. The real value of oil-coolers is in winter, since the desired viscosity in summer could be obtained very simply by using heavier oils. However, in winter, if heavier oils are used, starting may be difficult or impossible and oil-coolers, considered in this light, are devices to help starting in cold weather. If a heavy oil is required for normal operation in winter and a light oil is used for starting, it may be necessary to drive to a filling station and change oils before the attempt is made to operate the engine under normal operating conditions in cold weather.

Mr. Davis, who has charge of our cold room, has made several observations in carrying out experiments which were similar to those described by Mr. Wilkin. He found that, in making starting tests and then actually running the engine after starting, the torque values required for starting did not check as well as desired; also, that the trouble was due to the gasoline that condensed on the cylinder-wall and diluted the oil

[1] The paper was printed in the February, 1928, issue of THE JOURNAL, p. 213, under the full title, Motor-Oil Characteristics and Performance at Low Temperatures. The abstract that accompanied the paper is reprinted herewith, supplemented with a synopsis of the discussion. R. E. Wilkin is chemical engineer for the Standard Oil Co. of Indiana, Whiting, Ind. P. T. Oak and D. P. Barnard, 4th, co-authors with Mr. Wilkin, are research engineers for the same company.

[2] M.S.A.E.—Chief chemist, General Motors Corp. Research Laboratories, Detroit.

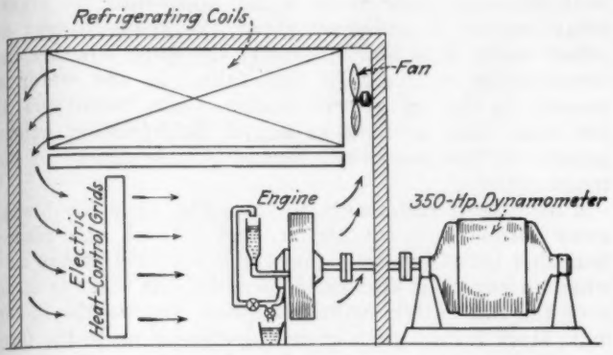


FIG. 1—TEST LAYOUT FOR OIL-CIRCULATION MEASUREMENTS AT LOW TEMPERATURES

between the piston and the cylinder. Since the amount of this diluent in the oil on the cylinder-wall varied with jacket-water temperatures, lower torque-values were required at starting if the jacket-water temperature was low when the engine was previously stopped. This effect of jacket-water temperature on the condensation of liquid on the cylinder-walls was pointed out by A. Ludlow Clayden in a paper on Water in Crankcase Oils[3].

These experiments also help to explain the easier starting experienced when an engine is stopped in cold weather by the use of the choke. It had previously been thought that the gasoline vapor remaining in the combustion-chambers was the only cause of subsequent easy starting, but Mr. Davis's tests show that, by the use of the choke on stopping, it is possible to have the oil on the cylinder-walls more highly diluted when the engine is started again, thus making the cranking speed higher. In fact, in one of these tests, he found the cranking speed so low that it was impossible to start a certain engine at 0 deg. fahr. using an oil of 300-Saybolt-sec. viscosity at 100 deg. fahr.; but, following the use of the choke on the previous stopping of the engine, a cranking speed sufficiently high to permit starting was obtained even though an oil having the same base and a viscosity of 500 Saybolt sec. at 100 deg. fahr. was used.

LUBRICATION OF AIRCRAFT ENGINES

RALPH N. DUBOIS[4]:—The connection between viscosity and pour-point determinations and actual performance data is very difficult to determine, and it is thought that the results of experiments made by me in the course of an investigation, conducted at the Bureau of Standards for the Bureau of Aeronautics of the Navy Department, of the problem of lubrication of aviation engines during the starting and the warming-up periods, may shed some light on the flow of oils through the engine at low temperatures under constant pressure.

A part of the work included tests of oils, submitted by manufacturers approved by the Navy, to find the oils most suitable for winter use in the more northern Air-Service stations. It was desired, further, to find the properties of the oils most closely related to their performance in the engines at low temperatures, so that specifications might be drawn to assure the purchase of lubricants suitable for this service. To this end about 35 samples of oils, mostly aviation oils of viscosities from 75 to 120 Saybolt sec. at 210 deg. fahr., were submitted by manufacturers for test.

These oils were first tested in the oil laboratory of the Bureau of Standards under the supervision of W. H. Herschel. The results were plotted on the Herschel viscosity-temperature chart shown as Fig. 8 in the paper. The viscosity of each oil was determined at 210 and at 100 deg. fahr. on the Saybolt viscosimeter, and at 32 deg. fahr. on the Bingham viscosimeter, where the oils were found to be non-plastic at the latter temperature. The pour-points were also determined. As might be expected, the results showed the viscosity at 210 deg. fahr. to give little indication of the low-temperature viscosity of the oils, those from different crudes differing widely in the slope of the viscosity-temperature curve.

For performance tests, a Wright Whirlwind radial air-cooled engine was mounted in a cold chamber in the dynamometer laboratory of the Bureau of Standards and connected to a 350-hp. electric dynamometer as shown in Fig. 1. The dynanometer was arranged to maintain a constant speed of 60 r.p.m. A determination of the rate of flow through the engine while being cranked at this speed was made for each oil. The tests were made at temperatures of —3 deg. cent. (27 deg. fahr.) and —6 deg. cent. (21 deg. fahr.), the arrangement of the piping being such as to maintain an adequate supply of oil at the inlet of the pressure pump at all times. A relief valve was adjusted to keep a pressure of 60 lb. per sq. in. at the pressure-pump outlet as shown in Fig. 2.

The results of these flow measurements, which covered a period of several months, showed the viscosity at the lowest temperature available, in this case 32 deg.

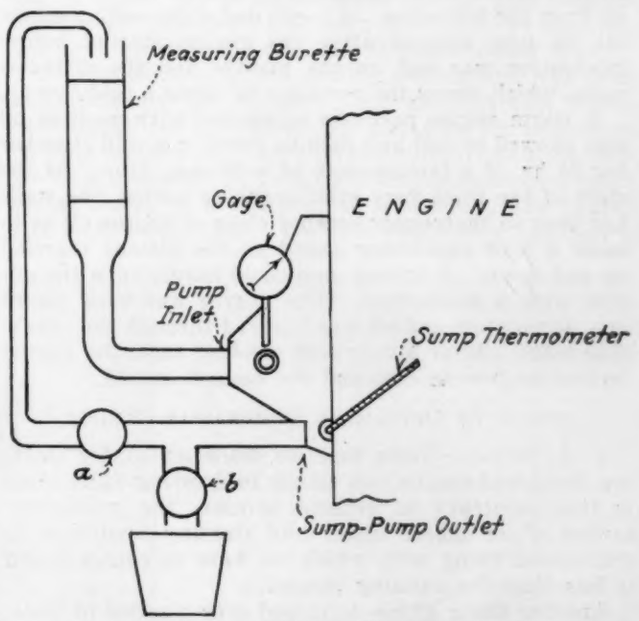


FIG. 2—ARRANGEMENTS OF EXTERNAL OIL-LINES

While Bringing the Engine to Test Temperature, Valve *b* Is Closed and Valve *a* Is Opened, Allowing Oil To Circulate Through Burette and Engine. After 4 to 5 Hr. of Operation at the Test Temperature, Valve *b* Is Opened and Valve *a* Is Closed. The Rate of Flow Is Then Measured by the Drop in Level of the Oil in the Burette

[3] See THE JOURNAL, July, 1924, p. 47.
[4] M.S.A.E.—Research engineer, A. C. Spark Plug Co., Flint, Mich.

fahr., to be the most reliable indication of the relative rates of flow of the oils under these conditions. Some of the oils, plastic at 32 deg. fahr., showed excellent rates of flow in the engine tests. As there was an adequate supply of oil to the pump at all times, there was no fluctuation in pressure and no "pour-point effect."

It is believed that the foregoing information may supplement that contained in the paper as regards rate of flow through engine lubrication-systems at low temperatures *after* flow through the pump has started. It is to be hoped that, with the advent of air-cleaners, crankcase ventilation, oil-filters and similar devices, the fine-mesh screen at the pump intake can be omitted and large, smooth-flow passages provided to enable some of the higher pour-test oils, which often have excellent viscosity-temperature characteristics, to be used.

Engine-Starting Test Described

C. P. GRIMES[5]:—Great interest in the change of viscosity of the paraffin-base oils under pressure seems evident. In an ordinary engine, with the oil-pump submerged in the crankcase chamber, pressure alone has little to do with the zero-temperature lubrication of the engine, because the oil must be sucked into the pump before it can be forced into the oil lines. A cornucopia-shaped entrance to the pump is formed in the cold viscous oil, after which only air is drawn into the pump and this makes it impossible to build up pressure.

During the process of making a paraffin-base oil into a cold-test product, the oil is chilled in the pipes, the wax chills upon the surface of the pipe and the fluid part alone flows through the center and out as a cold-test product.

In one test, electrically heated resistance wires were placed near the pump entrance and proved very effective until the heated oil had been sucked from contact with them and the intervening air insulated the remaining oil from the hot wires. At —20 deg. fahr. with medium oil, 12 min. elapsed after the engine started before lubrication was had on the pistons and the cylinder-walls, which shows the necessity of using a cold-test oil.

A warm engine perfectly lubricated with medium oil was allowed to cool and then to stand in a cold chamber for 24 hr. at a temperature of —20 deg. fahr. At the start of the third very brief cranking period, the walls had been so thoroughly scraped clean of engine oil as to make a loud squawking sound as the pistons traveled up and down. A strong man could hardly turn the engine with a hand-crank. The engine was then placed in a warm room and oil was injected through the spark-plug holes. After a very stiff one-half turn, the engine became as free as ever and the squawk ceased.

Tests To Determine Breakaway Torque

P. J. KENT[6]:—Tests that we made on winter starting developed one or two rather interesting facts. One is that, contrary to general opinion, the breakaway torque of an engine under cold starting conditions is the easiest thing with which we have to contend, and is less than the running torque.

Another thing which developed over a series of tests, made on the same engine at different temperatures and with the same grade of oil, is that apparently the breakaway torque is independent of the temperature; in other words, it is almost exactly the same whether the temperature is 70 or 10 deg. fahr. If any water is present in the oil and it freezes, these conditions do not hold; but, so long as actual fluid-friction exists, apparently the breakaway torque is independent of the temperature.

I have read statements to the effect that the breakaway torque is much higher, and I think one reason that this belief exists is the way a starting motor acts when an engine is started. Normally, the start is made with the full battery-voltage applied, and, as the motor must start from a state of rest and speed up to the final cranking-speed, the current draw is momentarily simply the battery voltage divided by the resistance of the starting motor. In other words, it is the stalled-torque current of the motor, and, as the motor speeds up, a counter-electromotive force is developed which reduces the current. So, starting under that condition, the current draw will rise to a higher value and then, as the speed increases, it will come down to a normal current-draw for the particular speed at which the engine is cranked.

If, however, a rheostat is connected in series with the line and the voltage is applied gradually, starting low and working up to a voltage at which the motor will just begin to turn over, a current draw will be obtained which is representative of the breakaway torque of the engine. It will be considerably lower than the current draw that occurs at 10, 20, 30 or 40 r.p.m. Within the range of cranking speeds, the current draw for any given temperature is almost proportional to the speed at which the cranking occurs. The current draw of a series motor is proportional to the torque; hence, for any given temperature, the cranking torque is proportional to the speed, up to a certain point. Beyond a certain speed, a condition is reached where the torque falls off relative to the speed. This is no doubt due to the freezing of the bearings and to piston friction during the interval from start to the time the higher cranking-speed is reached.

Measuring Oil-Film Shear-Resistance

G. A. ROUND[7]:—I cannot agree with Mr. Kent's statement regarding breakaway torque, as it is contrary to all our experience in engine tests and tests of other types.

To determine the low-temperature starting characteristics of oils of various types, we have used both poppet and sleeve-valve engines of different types. While the results obtained from these have been very consistent, the time required for the test work was greatly prolonged because of the need for repeated check runs for the elimination of variables. We therefore made up and tried several devices for the direct measurement of oil-film shear-resistance at low temperatures, with the idea that, having determined the performance of an engine with one oil by actual test, it would be possible to predict its performance on other oils by comparing the various oils on the test machine.

The instrument finally worked out consists of a shaft about 3 in. in diameter carried on plain bearings and driven through worm gearing by a ¼-hp. alternating-current motor. A sleeve or collar about 2 in. long and carrying a torque-arm is made to slip on over the overhanging end of the shaft with a clearance of 0.0025

[5] M.S.A.E.—Owner and manager, Grimes Brake Engineering Service, Syracuse, N. Y.

[6] M.S.A.E.—Accessory and electrical engineer, Chrysler Corp., Highland Park Plant, Detroit.

[7] M.S.A.E.—Assistant chief, engineering division, automotive department, Vacuum Oil Co., New York City.

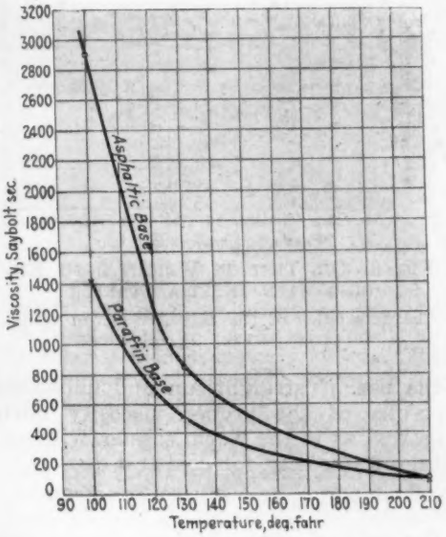


FIG. 3—COMPARATIVE TEST OF OIL VISCOSITY

Characteristics	Type of Oil: Asphaltic Base	Type of Oil: Paraffin Base
Pour Test, deg. fahr.	0	5
Carbon, per cent	0.62	1.78
Fire Test, deg. fahr.	540	505
Flash Point, deg. fahr.	465	450
Specific Gravity at 60 deg./60 deg. fahr.	0.942	0.912

in., the end of the arm resting on a knife-edge mounted on a scale. The rate of rotation of the shaft is such as to give a bearing-surface speed equivalent to about the average of the speeds of the pistons and bearings of an engine during the starting period.

In using this device, the parts are brought to a temperature a little above room temperature to prevent condensation of moisture on the oil-film, the shaft is well coated with oil and the collar is slipped on over it. The entire mechanism is then chilled to the desired temperature in the cold room, a thermometer-well being provided in the collar for the accurate determination of its temperature. The motor is then started with a snap switch. Observations are made of the torque at the instant of starting, and after 15 sec., when it has become uniform. The motor is then shut off, the parts washed with gasoline, dried and prepared for another run.

The results obtained with this instrument have consistently shown that they can be utilized to predict engine starting-performance using oils of various types. They also show that the breakaway torque is always greater than that at any subsequent period. Usually the "Go" readings, as we term them, are about 60 cent of those shown at breakaway.

It is interesting to note that this same difference is shown by tests conducted on a gear-shifting-resistance testing-machine of a radically different type. Further, the work done at Wright Field by the War Department Air Corps during the last year has shown the same indication. I therefore cannot help feeling that Mr. Kent's conclusions are in error, my reason being that, when very small forces are used, the rate of movement of the oil-film does not bear the same relation to the force as when larger forces are applied. We ran into that condition in our early attempts to develop measuring devices. With those acting at low velocity, we found that the results were not consistent with the engine tests.

FINE-MESH OIL-SCREENS UNDESIRABLE

Mr. Wilkin has stressed the importance of oil-screens. We agree that they are desirable for removing coarse impurities such as pieces of metal, wool, lint and large pieces of carbon, but they should not be expected to do the work of a filter in removing finely divided material. Fine screens of 40 to 60 mesh are very likely to clog unless of very large area. In this connection we have found from careful tests that the rate of flow through screens is inversely proportional to the relative clear-opening areas for non-turbulent flow. For turbulent, or high-velocity flow, the restriction with fine-mesh screens increases even more rapidly. Hence we feel that screens of mesh finer than No. 20 are undesirable and likely to give trouble.

DEWAXING PARAFFIN-BASE OILS

E. R. LEDERER[8]:—The paper corroborates some of the work we have done during the last year in our research laboratories. Because paraffin-base oils have a lower temperature-coefficient of viscosity than asphalt-base oils have, which is most important and desirable, the use of these oils is handicapped during cold weather because of their high cold-test; therefore, we have endeavored to lower the cold test of paraffin-base oils.

We do not use the cold settling-method and wax press mentioned by Mr. Grimes. We use Sharples Supercentrifuges for dewaxing. By changing the customary chilling method and the Sharples centrifuge somewhat, we have succeeded in fully dewaxing paraffin-base lubricating-stocks of a viscosity of from 50 to 180 Saybolt sec. at 210 deg. fahr. We have obtained a cold test of

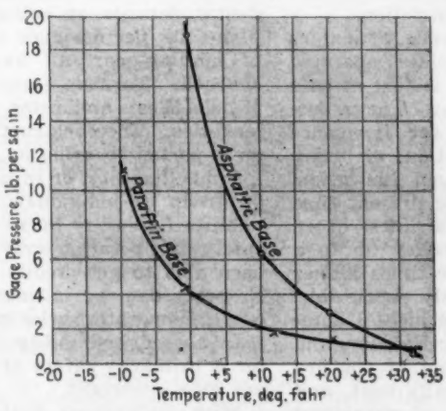


FIG. 4—FLUIDITY TEST OF OILS

The Orifice Was of 4-MM. Diameter and 15 MM. Long. The Flow Was 3.6 CC. per Min. The Characteristics of the Two Oils Were as Given under Fig. 3

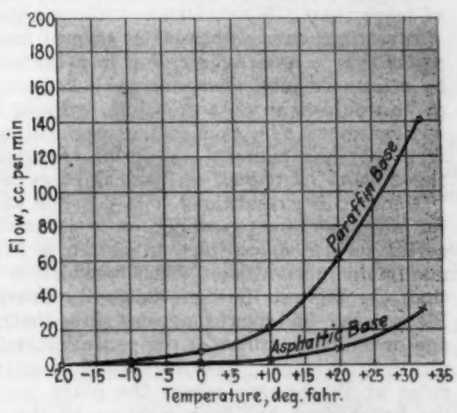


FIG. 5—FLUIDITY TEST OF OILS

The Orifice Was of 4-MM. Diameter and 15 MM. Long. The Gage Pressure Was 7 Lb. per Sq. In. The Characteristics of the Oils Were as Given under Fig. 3

[8]M.S.A.E.—Vice-president and director, Texas Pacific Coal & Oil Co., Fort Worth, Texas.

from 0 to 10 deg. fahr. on these stocks, averaging, generally, 5 deg. fahr.

We use in our testing laboratory an apparatus very much like the one in Fig. 2 of the paper. We do not call the viscosity at such low temperatures "viscosity"; we call it "fluidity." Tests on this apparatus comparing the flow of oils at various temperatures, all other conditions and viscosities at 210 deg. fahr. being equal, have shown that at a pump pressure of 5 to 7 lb. per sq. in., which is used generally for the lubrication of bearings in automobile and airplane engines, the fluidity is in favor of paraffin-base oils, regardless of the cold test.

Then we take our fully dewaxed paraffin-base lubricating-stocks having the viscosities and low cold-tests mentioned and test them in this fluidity apparatus at temperatures as low as —30 deg. fahr. We find that these oils have all the characteristics which Mr. Wilkin thinks desirable for low-temperature operation. Actual tests in our engine-testing laboratory and in the operation of automobiles and airplanes in cold weather have shown that these oils will build up sufficient pressure quickly and will give ease of starting and satisfactory lubrication at very low temperatures.

The fluidity curves of these oils are much flatter than the curves of asphalt-base oils or other zero-cold-test oils. We find that in actual tests and operation these fully dewaxed paraffin-base oils do not dilute as much as other oils, probably owing to better piston seal and the lack of necessity to use the choke as much during the starting operation at low temperatures.

Contrary to the general belief, the viscosity of these fully dewaxed paraffin-base oils does not increase unreasonably at temperatures below zero and, therefore,

[*] S.M.S.A.E.—Chief engineer, aeronautical engine laboratory, Naval Aircraft Factory, Navy Yard, Philadelphia.

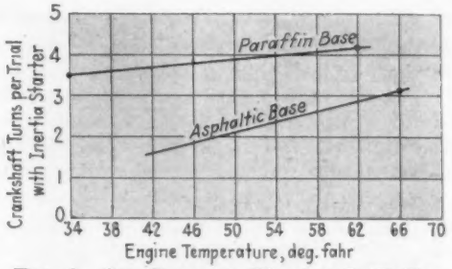


FIG. 6—OIL TEST ON WRIGHT J-4B ENGINE WITH INERTIA STARTER

Characteristics of the Oils Are Given under Fig. 3

permits the use of straight-run and unblended heavy lubricating-oils of the proper viscosity during cold weather as well as in the warm season, without forcing the sacrifice of viscosity for cold test.

COMPARATIVE TESTS OF OILS

J. H. GEISSE[*]:—Curves obtained from comparative tests of a paraffin-base and of an asphaltic-base oil, made by G. P. Toews, one of the engineers at the Naval Aircraft Factory, Philadelphia, are shown in Figs. 3, 4, 5 and 6. The curves in the first three figures are self-explanatory. In Fig. 6, those obtained on the Wright J-4B engine show the number of turns of the engine obtained from an inertia starter wound up to the same speed in each case. The test was made in connection with an endurance test of the oils in question. The engine was mounted on a torque-stand and was fitted with a propeller. The starting-friction tests plotted in the charts shown were made each morning before the engine was run. The tests for each oil were consecutive.

Insurance Covering Air Travel

AS a result of the steadily growing factor of safety in air transportation, 50 of the leading insurance companies of the United States and Canada are covering travel by air, if the policy holders wish to so travel, to the extent of more than $75,000,000,000 without any restriction.

Investigations conducted by several insurance companies prove that a passenger riding in a licensed plane, operated by a licensed pilot over an established route, is just as safe as he would be in an automobile, train or boat. The underwriters now are considering applications for insurance from persons engaged in aerial transportation, or using this means of travel, as normal cases without limitation.

Under these conditions it is possible at the present time for any pilot or passenger on commercial airlines, or in aerial service operations, to obtain a life policy up to a maximum indemnity of $50,000, which is five times higher than the highest limit of indemnity previously procurable. Planes may be covered against fire, theft, accidental damage or collision, tornado, compensation, public liability, and property damage. The fire rating is governed by the fire rates at the hangar where the plane is usually kept, and the fire hazard has been reduced by the use of metal and improved "plumbing." Theft insurance is not generally written, although a few planes have been stolen. It is expected, however, that this will be an important form of insurance in the future. Transportation insurance is usually treated incidental to the fire insurance and protects shipments in transit by air, just as commodities in transit by other means of transportation are protected.

There are many factors involved in the rating of accidental damage or collision. The inherent stability of a plane, its performance in landing and taking-off, its type of landing-gear, all have a direct bearing on the rate charged. Tornado insurance is almost a necessity in the Middle West, and rates on this coverage vary in different localities. The construction of planes and hangars also has an important bearing on the rate.

Public liability, or injury by an airplane to any individual or group of individuals, is actually a lesser hazard than liability for injury by an automobile. In fact, on account of safety in operation over a period of time, operators have been able to get credits on the rates they originally paid. Property damage is not a particularly serious hazard, except for operators who must fly over cities.

In passenger-liability insurance, the rate-governing factor is primarily safety of operation, although other features are also important.

With Federal or State regulation eliminating all unfit planes and pilots, and with constantly improving construction of aircraft, aeronautical insurance is approaching the point where it will be easy to place, broad in coverage, and at reasonable rates.—*The Wright Engine Builder.*

Independently Sprung Front Wheels

Discussion of the D. Sensaud de Lavaud Annual Meeting Paper[1]

THIS paper is an attack on the usual system of front suspension of an automobile and a proposal to substitute independently sprung front wheels for the conventional assembly of wheels, rigid axle and semi-elliptical springs.

Mounting of the front wheels on a solid axle is a survival of horse-drawn-vehicle days which the author asserts is so unsatisfactory from the standpoint of rational mechanics that it should long ago have become a memory in the automotive industry. To the complex action and reactions of the axle, oscillating between the springs and the tires, and of the wheels, with their gyroscopic effects, are attributed the phenomena of shimmy and wabble that have become so disconcerting and even dangerous since the advent of low-pressure tires and front-wheel brakes.

The origins of the various abnormal vibrations are analyzed, the effects of damping and of friction are discussed, and the part played by the conventional steering-gear and steering connections is considered. A distinction is drawn between damping and friction; the stabilizing effect of rake of the steering pivot and of deformation of the tires is explained, and the ineffective part played by friction shock-absorbers and by interleaf friction in the springs is described.

Rigidity and irreversibility of the steering mechanism are said to be most likely to induce shimmy at normal speeds with balloon tires and front-wheel brakes; hence the author advocates increasing the reversibility to the fullest possible extent and making the steering linkage sufficiently elastic.

The only specific remedy for abnormal front-end vibrations is, the author asserts, the adoption of correct independence of the front wheels, and he shows and describes a design that he has developed for such a construction.

He does not regard a similar independent suspension for the rear wheels as very desirable, but if such a suspension is to be used, he thinks it is better to adopt a split rear axle.

In the discussion, some of which was oral at the Annual Meeting and other, including that by the author, was submitted subsequently in writing, the findings from studies of front-end phenomena are declared to check closely with those of the author. One research organization found that shimmy frequently occurred when the wheels were in synchronism with the natural torsional frequency of the frame and body; also that, with the steering tie-rod removed, the same shimmy effect was obtainable as with the tie-rod in place.

Another. organization found that shimmy and tramp were completely eliminated if the steering-gear was bolted to the axle and connected rigidly to the steering-knuckle arms. By restraining either tramp or shimmy, both are restrained, as was proved by road tests as well as on the dynamometer.

A third investigator agrees that the author's mathematical analysis is excellent but disagrees with his assumptions, as no front-wheel suspension has been devised, he asserts, that completely avoids a rocking motion of the front-wheel plane with relation to the car frame. He thinks that independent-wheel suspension will not suffice to suppress shimmy and must be supplemented by steering-complications. It has been found that a simple modification of the conventional steering system completely eliminates shimmy.

Objection is made to the author's design on the ground of expense of construction, and it is pointed out that European constructors have attacked the problem of shimmy without knowledge of the riding-qualities problem presented in this Country by certain types of road which set up small oscillations that can be absorbed only by suitable springs.

Replying to each critic, the author supports his theory and maintains that his construction is the only solution of the problem and is neither complicated nor expensive.

CHAIRMAN W. R. STRICKLAND[2]:—This analysis of the subject of car suspension has received much favorable comment. While it may seem to point to the author's own conclusions, it will be of value to all of us regardless of the conclusions, as undoubtedly we can benefit and have already benefited, in a great many ways, from its study.

The sweeping condemnation of our present system is not so good, because the vehicles of today are certainly practical and dependable, whereas, if the type of vehicle the author describes were operated in this Country in such numbers as present cars, there is no way of telling what the final results would be. The riding-quality problem, which we cover rather carefully in this Country, is hardly known abroad. In the operation of American cars in Europe, we find that the conditions are very different, requiring totally different springing and shock-absorbing apparatus.

Axle tramp, wheel wabble, and related phenomena are explained a little more scientifically than they have been in previous papers presented in this Country. However, with the knowledge we have in this Country, we have been able to minimize all phases of shimmy by improving the details of the mechanism along some of the lines M. de Lavaud has pointed out.

The whole paper is based on a design to take care of

[1] This paper was published in the June, 1928, issue of THE JOURNAL, p. 623, under the full title, Independently Sprung Wheels as a Remedy for Shimmy. The author is an engineer, of Paris, France. The abstract of the paper is reprinted above, supplemented by a brief synopsis of the main trend of the discussion printed herewith, for the convenience of the reader.

[2] M.S.A.E.—Assistant chief engineer, Cadillac Motor Car Co., Detroit.

four-wheel brakes and low-pressure tires. When low-pressure tires were introduced they were expected to be operated at extremely low pressures that were found to be impractical. We now use higher pressures and stiffer carcasses, and have been able to satisfy the American public at any speed.

One of the difficulties which engineers and constructors abroad apparently know nothing about in the riding-qualities as affected by low-pressure tires is the severe, very small oscillation on good pavements, as on a concrete road having an expansion joint every 60 ft. or so, which becomes very disagreeable. If one relies on the low-pressure tire to cushion this effect, he will be greatly disappointed. The successful way of absorbing this oscillation has been to make the springs work. When the springs work, they have a damping effect that prevents these very small vibrations getting through to the passenger. This effect, of course, is assisted by various kinds of shock-absorbing equipment.

While, from knowledge of their own conditions, the European constructors object to carrying what we call moderate pressures in the tires instead of low pressures, the shimmy problem has been taken care of rather well with the improvements we have made to date.

Conservative Rejection of Progress an Error

D. Sensaud de Lavaud:—I do not see the value of an argument which rejects progress arbitrarily because it requires a little greater complication and costs a little more. Every machine that is improved little by little must become more complicated; to follow such logic and to retain the original simplicity is to deny all progress. It is also an error from the commercial point of view, because the customer always is willing to pay a little more to obtain a real increase in comfort, convenience and ease of operation.

Concerning the objection of the minute oscillation created by certain American roads, the use of rubber in the suspension is favorable. Everyone knows that rubber absorbs such vibrations particularly well.

I regard the condemnation of the customary front suspension as beyond discussion. Mechanical principles are the same in all countries and arguments in regard to the condition of the roads is valueless, in my opinion. Suspension and steering have been improved, but it is better to adopt a rational solution than to spend the time and money to make bearable a mechanism that is imperfect even in its principle.

All new ideas encounter conservative resistance to their adoption, but this resistance can result only in hindering progress, without being able to prevent the inevitable evolution. I am persuaded that the future belongs to independent suspension of front wheels, because logic shows that it is the only plan that meets completely and rationally the many requirements of modern vehicles.

Results of Stroboscopic Study of Shimmy

C. R. Paton[3]:—The experience we have had with the use of a stroboscope in studying shimmy checks very closely in general with what the author presented in his paper. About two years ago we started some shimmy tests, using the chassis-dynamometer equipment that was available at the University of Michigan. I think the drums are about 6 ft. in diameter, equipped with wood lagging. We mounted a car on the drums and with a Davies stroboscope obtained some very interesting impressions as to just what was occurring.

In general, we found that the movements were substantially as the author has pointed out. They were governed to a large extent by gyroscopic forces, but there is one point on which we differ slightly with the author, who states that the tramp and wabble movements are in phase. We find there is a lag; that the elliptical path described by the hub does not have its major axis vertical. In other words, when the axle is horizontal the wabble movement is not necessarily at the extreme right or left position. In all of our tests we have found the major axis of the hub ellipse to be inclined from the vertical, indicating a definite phase lag. One would expect this lag, when the friction which is bound to exist is considered. If the system were frictionless, there might be no lag.

Another interesting experiment checks the gyroscopic theory. When we removed the steering tie-rod and operated the car on the chassis dynamometer, we obtained substantially the same shimmy as we did with the tie-rod in place. These observations support the point the author has made, that the mechanical connection is not needed; the gyroscopic couples are of sufficient magnitude to cause the disturbance observed.

Frame and Body Frequency a Factor

The author considers natural frequencies of two movements: tramp and wheel wabble. He also states that shimmy occurs when the frequency of the wheel revolution corresponds with the natural frequency of tramp. That may have been, and no doubt was, true in the experiments he conducted, but we have found it is not necessarily true with all cars. Since our engineering department was moved to South Bend, we have installed a four-wheel chassis dynamometer which has made possible a rather close study of a large number of different cars, and we have checked the natural frequencies of wheel wabble and axle tramp. There is always more or less wabble when there is tramp, and the converse is true, there is more or less tramp when there is wabble—the two are interrelated by the gyroscopic couple; but in addition we have measured a third natural frequency, that of the frame and body in torsion.

We find that, when a car which will shimmy at say 65 m.p.h. on the road is put on a chassis dynamometer, the natural frequency which corresponds to the 65-m.p.h. period is that of the frame or body, not that of tramp or wabble. If it were wheel revolutions corresponding to natural frequency of tramp, the shimmy would occur, with the particular car in mind, at about 47 m.p.h., but we do not get any serious disturbance at that speed. This indicates that, in the case of many cars, shimmy really occurs when there is synchronism between the wheel-revolution frequency and the natural torsional frequency of the frame and body.

Of the three vibrating movements which we found to be involved in shimmy, i.e., wheel wabble, wheel and axle tramp, and frame and body torsional vibration, the first two movements can be highly damped, at least experimentally, so that their maximum amplitudes will be small, but it is rather difficult to provide adequate damping of the vibrating system represented by the frame and body in torsion. If frame and body could be damped to reduce torsional vibration, I believe that the

[3] M.S.A.E.—Laboratory engineer, research division, Studebaker Corp. of America, South Bend, Ind.

tendency of the car to shimmy would thereby be materially reduced.

Another method of attacking the problem is to raise the shimmy period above the normal driving range. Increasing the torsional rigidity of the frame and body structure has been considered, but this requires a major increase of rigidity to obtain a minor change in the torsional natural frequency. Increasing the tire diameter, thus increasing the road speed at which the wheel frequency synchronizes with that of the frame and body, is a second method of attack. Unfortunately, the present tendency is to decrease the tire diameter, which has the effect of lowering the shimmy period in the driving range.

Shimmy occurs to a serious extent when the magnitude of the energy input per cycle exceeds the magnitude of the damping available per cycle. Energy input per cycle increases rapidly with increasing amplitude; therefore, to control shimmy, we must apply damping very promptly to keep the amplitude small. That leaves us with the riding-qualities specialists on the one hand and, on the other hand, the man who is trying to suppress shimmy. For good riding we want a free center; for the avoidance of shimmy we do not.

Influence of Friction and Damping

M. de Lavaud:—The general law of oscillation of a front assembly, to which Mr. Paton refers, assumes neither friction nor damping. The equations I have developed do not allow for these two factors, which I introduced later in the discussion of stability.

In a system of multiple oscillators, it is true that friction or damping causes disagreement in the phases. It is therefore useless to take them into account in computing the principal periods to determine the conditions of resonance. This is outside the subject of resonance. That is why I have not considered them in the first part of my study of critical speeds and resonance. However, these factors should be introduced in the analysis of stability of oscillation, because instability is strictly dependent upon friction, on the one hand, and damping, on the other.

On this subject I should make here an important remark regarding the way in which the problem of double steering is related to the usual front-end assembly. During the principal oscillation of a front assembly having no steering cross-connection, the surging motions of the wheels around their pivots are no longer in phase if they are influenced by friction or damping that differ materially from each other in their effect. The question does not arise with the ordinary steering cross-connection, because the two wheels become a single oscillator whose friction and damping are the sum of the friction and damping of the individual wheels.

Let us suppose the case of quite elastic double steering without direct connection between the two wheels, in which the elasticity of the steering-gear, the friction and the damping are different. The front system should then be considered as one having three distinct oscillations, with reciprocal reaction. Three distinct principal oscillations generally are superimposed upon one another in a natural oscillation, and accordingly, there are three periods. We find thus that it is possible to have two critical speeds of wabble and one of shimmy. The various elasticities do not at all prevent the agreement of phase in the movements of the wheels, but it is not the same with friction and damping, which, by their inequalities, can cause a sensible disagreement in phase. It is evident that, under these conditions, shimmy can be prevented. For this reason, it is sometimes possible completely to avoid shimmy with double steering and the usual front-end construction.

It is advantageous, then, to give a different angle of rake to the wheels, because the angle of rake, by virtue of its righting influence, gives an important dynamic damping. In a word, double steering separates the two oscillators and makes possible the advantage of differentiating their phases.

It is quite evident that, to verify experimentally this effect of eliminating the steering cross-connection, it would be necessary to cause the zigzag motion of the car which requires the angle of rake. If the observation is limited to the simple oscillation of the front-axle assembly, it always proves an agreement of phase a little more complete, because the differences in friction and natural damping are never very great.

As to agreement between the natural frequency and the time of one rotation of the wheel, one natural oscillation of the front axle includes, theoretically, three distinct superimposed oscillations, of which I have shown only two. Resonance affects only one of the oscillations that need to be considered; agreement is necessary between the frequency of one rotation of the wheel and that of the oscillating elements which are in synchronism. This is an absolute principle, and if experience does not verify it, that is because other superimposed parasitic oscillations falsify the observations, or because the question is not one of resonance but rather of instability. In the latter case, the time of one revolution of the wheel does not enter; the instability can appear at any speed whatever above a certain fixed speed depending upon the natural damping.

Restraining One Motion Restrains Both

George E. A. Hallatt[1]:—M. de Lavaud's paper is a splendid and thorough piece of work, and his findings are largely in accord with our own in some research we conducted several years ago on the problem of front-wheel instability. M. de Lavaud shows that the zigzag motion attained by the car is one of the major considerations in this problem. We feel that it comes under the heading of what he calls parasites and is not one of the fundamental considerations.

In attacking the problem of front-wheel instability, we reasoned that, if anything caused the front wheels to turn on their pivots laterally, as in shimmy, a certain amount of rocking of the axle was bound to occur through the principle of the 90-deg. law of gyroscopes, and that, if anything caused the axle to oscillate about its center, raising one wheel and lowering the other, as in tramp, it was bound to result in more or less shimmy for the same reason. Reasoning from this, it seemed that if we could restrain either of these two movements it would result in stopping the undesirable oscillations.

We placed front wheels of the most consistently shimmying car we had upon the rollers of a chassis dynamometer and were pleased to find that the wheels shimmied and tramped just as they did on the road. We then blocked the steering-knuckles so that they could not turn on their pivots, and there was neither shimmy nor tramp at any speed. Next we removed the blocking

[1] M.S.A.E.—Head of powerplant section, General Motors Research Laboratories, Detroit.

from the steering-knuckles and bolted the front axle to a solid floor so that it was impossible for it to tramp in the slightest degree, and then found that we also had no shimmy. The only detail remaining to be worked out was how to do either of these things on the road without affecting the ease of steering or the softness of the ride.

It may be well to point out that we believe the only reason the rear axle does not tramp is because it cannot shimmy. We tried stabilizing the front axle or preventing tramp by applying the harmonic-balancer principle, and succeeded experimentally but not practically. Later we found that, if we bolted a steering-gear to the front axle and connected it rigidly to the steering-knuckle arms, this completely stopped shimmy and tramp, even though the gear was of only ordinary irreversibility.

Another point on which M. de Lavaud seems to agree with our work is that much of the so-called "road-fight" or steering-wheel whip is but single cycles of gyroscopic shimmy, and that if one front wheel is driven over a bump at high speed it will twitch the steering-wheel in an ordinary car, but if steps such as those outlined are taken to prevent shimmy, no twitch will be given the steering-wheel when one wheel runs over a bump. My point is that most steering disturbances pointed out by M. de Lavaud can be remedied even though the conventional axle is used, though I do not for a moment deny that separately sprung front wheels are also a sound way of overcoming the trouble.

We feel that the general phenomena of shimmy, tramp and wheel fight can be split up, as M. de Lavaud has done, into many minor phenomena, but that this is unnecessary; that all major disturbances can be traced to the principle of gyroscopic interrelation between shimmy and tramp, and that, by restraining one of these motions, both are inevitably restrained. This has been thoroughly proved on the road as well as on the chassis dynamometer.

Rear Axle Cannot Oscillate Seriously

M. de Lavaud:—When a group of multiple elements oscillates, the amplitudes agree exactly with that of one of them. It is accurate to say that, if the movement of one of the oscillators is stopped, the movement of all is stopped. The experiences of Mr. Hallett therefore agree fully with this general principle.

It evidently follows from this that the rear axle is never subject to serious oscillation, because the wheels cannot have a vibrating motion. It is not necessary to conclude that there are no gyroscopic reactions at the rear; when one rear wheel rises over an obstacle, the rear axle receives a gyroscopic impulse tending to make it turn around a vertical axis at its center of gravity; but, since this movement is prevented, no oscillation results from it.

De Lavaud Construction Good but Expensive

Walter C. Keys[5]:—I think we are all handicapped in commenting on the author's spring-suspension because we have not had the opportunity to ride in and to drive his car. I should like to have that opportunity, and intend to make it possible soon.

The construction appears to me to be considerably more expensive than the conventional spring-suspension used on American cars, and the addition of $1 or $5 in cost is rather serious in these days. The telescoping pivot presents the necessity for an absolutely watertight boot, without which trouble will certainly develop. Such boots, while not impossible, present difficulties.

The use of rubber as a spring is basically desirable because of the inherent ability of rubber to dissipate energy within itself by conversion of energy into heat. The laminated construction of alternate rubber and metal washers is desirable as a means of maintaining fairly uniform and reasonably low stress within the rubber. Rubber resists deformation because of its cohesion or tensile properties, and its adhesion to solid unlubricated substances against which it may be pressed into contact. This adhesion, in the case of laminated construction, acts to prevent excessive deformation and its attendant high stress. M. de Lavaud's construction therefore looks good as regards rubber distribution. It is undesirable, however, to place rubber in constant contact with oil or grease unless the rubber is specially compounded for such use, in which case its physical properties generally are impaired. The construction shown leaves some doubt in respect to this point. Judging from the cross-section drawing of the front-axle end, it seems to me that the rubber spring must either lack adequate flexibility or be too highly stressed. The telescoping members are adapted to possible modifications of natural flexure and rebound through the restriction of air passing into or out of the cylindrical members.

Front Construction Not Difficult To Make

M. de Lavaud:—Agreeable to the desire of Mr. Keys, I shall be pleased to show my car in America as soon as I am able.

I do not believe that the front construction, as I visualize it, will be more difficult to manufacture than the customary design, because it contains only very simple parts. The telescopic pivots are watertight; and, even if water enters accidentally, it will have no injurious effect upon the rubber. I can say, after a long trial, that this mounting has shown no practical difficulty. It is possible to make the rubber work in oil without injury; special rubber is now made which answers this purpose perfectly. I have succeeded in giving to the rubber washers an initial form such that they do not rub on the metal at all as they are deformed. This is one of the essential points of my suspension.

Correct Analysis on Unwarranted Assumption

Eduard Zap[6]:—While agreeing completely with the analytical part of M. de Lavaud's excellent paper, some of his conclusions are not quite convincing to me. He states that, if we avoid any axle tramp or equivalent rocking motion of the front-wheel plane, no shimmy vibration can develop. Unfortunately, none of the front-wheel suspensions devised up to the present avoids completely such a rocking motion of the front-wheel plane. There are designs that force the front wheels to move in planes vertical to the chassis. Compression of one of the suspension springs will keep the wheel in a plane vertical to the chassis, but the rocking of the chassis toward the side on which the spring has been compressed will induce rocking of the front-wheel planes, thus inducing the objectionable gyroscopic effect.

The same holds true for the arrangement proposed

[5] M.S.A.E.—Chief engineer, automotive development department, United States Rubber Co., Detroit.

[6] M.S.A.E.—Development engineer, Chrysler Corp., Detroit.

by M. de Lavaud. The front-wheel planes will rock because of the rocking of the bar used by him to replace the conventional front axle. This seems to indicate that independently sprung front-wheels, while reducing somewhat the shimmy vibration, do not prevent it completely. Inspection of M. de Lavaud's car seems to corroborate this statement.

The suspension used is probably very satisfactory as regards riding-quality. To suppress shimmy, this suspension had to be supplemented by independent steering of the front wheels and a reversible steering-gear with a hydraulic damper. The driver is supposed to adjust this damper while driving the car to suit the driving conditions. Thus, three marked complications in the car design had to be used. None of them if used separately could suppress sufficiently the shimmy vibrations. The complication involved by the use of independently sprung front-wheels may be justified by the resulting improvement in riding-quality. The double steering and the adjustable hydraulic damper on the steering-gear must be regarded as expensive and uncomfortable complications.

A Simple Remedy with Conventional Design

I have found, in complete agreement with M. de Lavaud, that the vibrations called shimmy are due to the oscillations of a system, represented by the front axle with its wheels, having two degrees of freedom. This system is connected with the frame through the suspension springs and through the steering-gear connecting-rod and the steering-gear.

Instead of changing the mechanism so radically as is proposed by M. de Lavaud, modification of its connection to the steering-gear by interposing in the linkage a yielding member of simple design has been found effective in completely eliminating shimmy and wheel fight. The yielding characteristic of this member has been so chosen as to change radically the vibration characteristics of the system. This apparently slight modification changes the properties of the system fundamentally from a physical point of view, without necessitating any radical change in design, so that the system no longer fulfills the assumptions on which M. de Lavaud based his analysis. Therefore the changed system is not subject to the shimmy and pseudo-shimmy defined by M. de Lavaud, but makes the elimination of shimmy vibrations possible while using conventional axles and steering.

This shows the necessity of careful investigation before accepting the assumptions on which a mathematical analysis is based. Conclusions drawn from a mathematical analysis that is absolutely correct in itself might suggest modifications in design which would prove successful, but one should not forget that, instead of complicating a design to accord with the conclusions, a slight modification of the layout may alter the assumptions of the mathematical analysis and give the desired result by much simpler means.

Damper Unnecessary with Independent Wheels

M. de Lavaud:—I do not agree with Mr. Zap. It is very evident that, with independent front wheels, the tipping of the whole chassis by compression of the springs and the tires on one side and their extension on the other side causes a slight gyroscopic reaction, because the wheels are inclined. The movement of the wheels always being slow, the resulting reactions are negligible. No resonance is possible from natural reactions of this sort because their frequency is much too low.

The general theory of shimmy and the related phenomena can be based entirely upon mechanical principles, and it is indisputable that, to induce the phenomena under discussion, gyroscopic interaction is necessary between the axle and wheels and not between the wheels and the chassis. With independent wheels and reversible steering, it is possible at high speed to feel in the steering the direct effect of unbalance in a wheel without any tendency to shimmy. Eliminating any too pronounced unbalance in the wheels is sufficient to remove the possibility of the least evidence of abnormal vibration.

It is inaccurate to say that, to suppress shimmy, double steering with independent wheels needs to be supplemented with an hydraulic damper. Although I originally provided such a damper on my car, it was for the sole purpose of resisting any steering reaction. Experience has proved to me, beyond argument, that this was absolutely useless.

Concerning the elasticity of the steering mechanism, computations have led me to the same result as have Mr. Zap's experiments. Elasticity is needed in the steering mechanism according to the pressure in the tires and the weight of the wheels. This is the best palliative, but it cannot give the comfort and ease of steering that can be obtained from a correct suspension with independent wheels.

Independence of gyroscopic effects should be provided at the front only, in a way to make the axis of sidesway inclined downward toward the front. There is also, through a sort of damping, an automatic stabilizing of the wheels so great that it is readily noticed. Besides the suppression of gyroscopic reaction, there is a very important supplementary advantage that allows the use of a very soft suspension at the rear, with no undesirable effect.

Suppression of Gyroscopic Reaction Prevents Shimmy

I believe that a number of engineers in the United States have investigated the question of shimmy experimentally, and that their conclusions agree with my theory. It is certain, from the point of view of mechanical principles, that the problem can be reduced to an analysis of the vibrating conditions of a system having several oscillators. Under this condition, the disturbances can originate only from resonance induced by an unbalance of the wheels or from natural instability of the oscillating system.

I insist particularly that resonance alone is insufficient to explain all of the phenomena. The important fact is the tendency to instability resulting from gyroscopic excitation due to the zigzag motion of the vehicle. When the oscillations are stable, that is to say, naturally convergent, this tendency reduces the natural damping, which explains the possibility of intense resonance combined with a slight lack of balance. If, on the contrary, true instability is shown, every symptom of shimmy can be obtained without any disturbance from unbalance of the wheels. Synchronism between the speed of rotation of the wheels and a natural period of vibration is then a condition that permits abnormal vibration, but it is not the only condition. From the point of view of mechanical principles, there can be no

doubt that a suspension with independent wheels cannot induce shimmy.

I define independence of the wheels to mean that, in their free displacement, the axle and the wheel are subject only to translation. Because of this, the gyroscopic reactions are suppressed and the problem of shimmy cannot arise. In fact, shimmy results from gyroscopic reaction between various oscillating members and reciprocating connections. With independent wheels, there are neither oscillating members nor gyroscopic reaction; consequently, there is no longer any occasion to consider shimmy.

My car has enabled me to prove experimentally that the reactions received in driving are of gyroscopic origin. The front beam, which takes the place of the usual axle, turns with considerable friction at the center of the front of the frame; the wheels are mounted independently at the two ends of the beam on rubber. When the beam remains fixed, the axis of neither wheel can move except in a parallel direction. The independence is complete, notwithstanding the gyroscopic effects. It is not the same when the beam is free to oscillate.

The following phenomena can be observed:

(1) With the normal tight adjustment of the beam, so that the usual inequalities of the road must displace the wheels without inclining the beam, even on the worst road no steering reaction can be felt with a completely reversible steering-gear and no steering damper. Only extremely rough roads incline the beam, so that it relieves the chassis of any great amount of torsion.

(2) If, under conditions otherwise the same, the adjustment of the beam is loosened, violent reactions are felt from the road immediately, and steering becomes extremely difficult.

Double Steering Adds No Complication

It is not correct to say that double steering, which such a suspension requires, presents any added complications. There is no need of an hydraulic damper, as experience has shown me. I have already considered such a damper and am convinced of its uselessness. The usual steering tie-rod between the two wheels is unsuitable in every way. It prevents the steering lock from being correct for more than a few degrees, whereas on my car I have succeeded in obtaining a lock of as much as 48 deg. that is strictly correct throughout.

Finally, the advantage of independent suspension of the wheels does not depend entirely upon the suppression of shimmy. Such suspension suppresses absolutely all road reaction from steering and makes possible the use of a reversible steering-gear. A trial of such a mechanism is sufficient to show its marked superiority. The gyroscopic effect of the usual front-end construction is acting constantly; it requires a degree of irreversibility which otherwise is useless. Powerful shock-absorbers, which are a barbarous palliative, are needed. It is true that thus the mechanical imperfection of the mechanism can be tolerated, but it is impossible not to recognize the gross error in principle.

New Cuban Highway and Automobile Imports

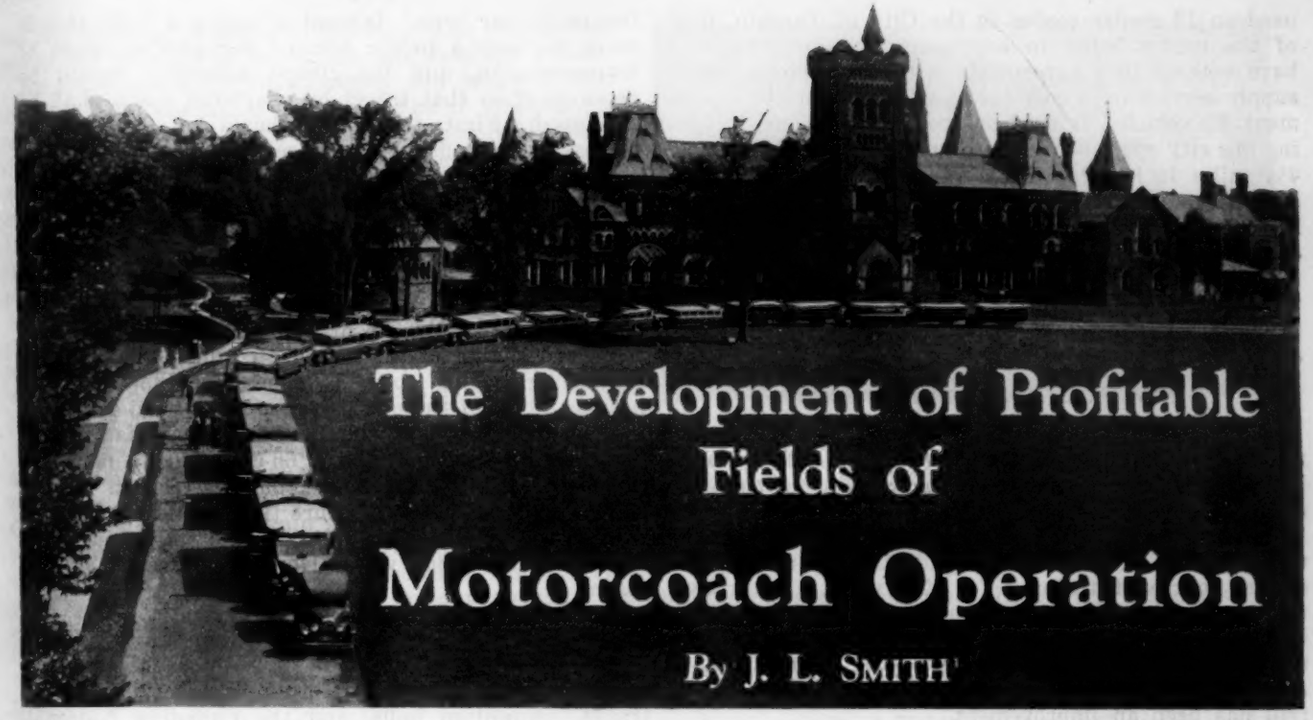
WITH the completion of Cuba's new central highway anticipated 2 years hence, the most outstanding handicap to the development of the automobile industry in that country will have been removed, according to Assistant Commercial Attaché Merwin L. Bohan. This great national highway will traverse the island from one end to the other and be connected with the towns and villages along its route by lateral roads.

The extension of motor-vehicle traffic in Cuba has been definitely restricted by the inadequacy of its roads, especially those in the country areas. The island has more than 5000 miles of city streets and 1600 miles of country roads, of which it is estimated not more than 15 per cent is now favorable to the use of automobiles.

On June 30 last approximately 43,000 motor-vehicles were registered in Cuba, which was a gain of 4700, or 12 per cent, as compared with the previous fiscal year. The greatest increase was in motorcoach registrations, which rose 48 per cent; truck registrations advanced 25 per cent, while passenger-cars showed the smallest gain, only 6 per cent. Exclusive of the Government-owned trucks, there are about 11,000 of this type of motor-vehicle in Cuba today. It is significant that more than 62 per cent of the registered passenger-cars are used for hire. More than 60 per cent of the total number of motor-vehicles registered in Cuba are in the Province of Havana.

American automobiles are most popular in the Cuban market, imports of European makes averaging not more than 2 per cent annually. The economic depression which has existed in the country for the last few years has been reflected in its motor-vehicle purchases. In 1927 American exports were valued at $5,290,000 as compared with $4,500,000 in 1926 and something more than $6,000,000 in 1925. In 1920, the peak year of the island's prosperity, American shipments of motor-vehicles to Cuba reached a total value of more than $10,000,000. Of the 1927 exports of 6325 units, 1842 were trucks and motorcoaches valued at $1,500,000.

While the immediate prospects for increased automobile sales in Cuba are not so promising, the outlook for the next 2 years is optimistic. During that period a considerable part of the new highway will have been completed, resulting in an increased local demand for both passenger and commercial cars. Better conditions in the sugar industry would also stimulate the demand, but in the long run the market will develop toward its potentialities only on the completion of the road-building program. At present the ratio of automobiles to people in Cuba is 1 to 94 as compared with 1 to 5 in the United States. It may be reasonably assumed that this ratio will be radically lowered when the country areas now inaccessible to motor-vehicle traffic are opened by the new highway. The trend of motor-vehicle sales then in Cuba during the next 5 years should be distinctly upward.—Department of Commerce bulletin.



The Development of Profitable Fields of Motorcoach Operation

By J. L. SMITH[1]

SEMI-ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS

DISTINCTION is drawin between special motorcoach services, that increase the volume of patronage and produce increased profit, and certain travel comforts or luxuries, that reduce the seating capacity and require extra fare. Many operating companies have failed, according to the author, because they have not given enough consideration to this difference and have been too "freakish" instead of being content to add the "frills" that develop increased business.

So-called frills adopted by his companies that in three years have tripled the revenue from motorcoach operation, as differentiated from feeder services, are pneumatic tires, six-cylinder parlor-car coaches, sightseeing service in which the guides are university students, the chartering of special coaches to parties for trips of any length, special service during off-peak hours for special events, the maintenance of attractive and well-equipped terminal and comfort stations on regular interurban routes, clerks fully posted regarding connecting lines, correct and concise timetables showing connections, and a suitable souvenir booklet mentioning historic places and events along the routes.

Freakishness that may prove disastrous is mentioned as including the providing of salon or semi-salon coaches having ice-water tanks, lavatories and other luxuries the object of which is defeated if they are not carefully maintained and that may reduce the seating capacity by four seats. To make the operation of these profitable, higher fare must be charged, and, in the author's opinion, the volume of business should be sufficient to warrant sending out double-headers on the trips.

Much additional information is brought out in the discussion, which relates to factors that are important in making a motor-transportation line profitable; the selecting and handling of drivers; their working hours and wages; the earning rates per mile of coaches in special services; results had with dual pneumatic tires; the double-header operation of city-type and de-luxe coaches on interurban routes; the effect of city motorcoach operation on street-railway revenue; replacement of street-car service with motorcoach service; size of city that can be served adequately by motorcoaches; the extent to which city coaches should be loaded; and the development of connecting-line traffic and its advantages.

LARGE-SCALE motorcoach operators, especially those engaged in interurban work, often wonder just what frills they can add without becoming freakish or without spending money on which there will be no commensurate return.

The Toronto Transportation Commission and the Gray Coach Lines, a subsidiary of the former, have had a fairly rapid growth since March, 1925, when they branched out into general coach operation. In 1925 the commission owned 20 vehicles and it now operates 156.

One of the first frills, if it can be classed as such, was the change from solid to pneumatic tires, not only on the new vehicles purchased, but on the original purchases. After this change in March, 1925, all new purchases were six-cylinder motorcoaches. Our experience has proved this type of vehicle to be more satisfactory for our operation, although some operators still favor the four-cylinder type. Sixty-three vehicles are now

[1] Superintendent, motorcoach department, Toronto Transportation Commission; general superintendent, Gray Coach Lines, Toronto, Ont., Canada.

used on 13 feeder routes in the City of Toronto, four of the routes being in adjoining municipalities that have entered into agreements with the commission to supply service on a cost basis. The rest of the equipment, 93 vehicles, is used on special operations, including one city special-fare route known as the Hill Route, 4¼ miles in length, with a fare of 15 cents cash or eight tickets for $1. A parlor-type coach is used, seating 29 passengers, and no standees are allowed. The coaches on this route are operated 1100 miles daily through high-class residential districts. The operation is a financial success and does not deprive the street-railway of any revenue, as the majority of passengers are former motor-car users.

A New Frill in Sightseeing Service

Sightseeing in Toronto for four months of the year requires 15 parlor-type coaches, specially designed and built in the commission's own shops. On big days as many as 40 coaches have been engaged on this work. Differing from former sightseeing days, the guides on these coaches are university students who undergo a special course of training for this work. Naturally, their university education is helpful, and the tourist is impressed by their perfect pronunciation, their demeanor and their eagerness to please. Anyone who remembers the old system will agree that herein another frill has been an improvement.

Extensive Chartered Work Profitable

Few companies would buy motorcoaches for chartered work alone, and in my opinion they are right. Nevertheless, chartered work is one of the most profitable of our undertakings, because we endeavor to operate this service during the off-peak hours. Gray Coach Lines will operate 200,000 miles during 1928 in this particular line of work, using almost solely coaches of the parlor-car type. Instead of being a frill, this is more to meet a public demand for another mode of transportation, and the closest attention should be given to it so that travel by chartered coach shall be developed. First, the driver should be selected, and, if possible, an official should see the chartering party started. If a number of coaches are going, it is advisable to send an inspector along to attend to any small details that may be necessary.

We never miss a day throughout the year without a chartered coach in operation and, in the height of the season, more than 60 coaches have been engaged on one contract. A line-up of coaches on a typical chartered order, that of the American Library Association for a sightseeing tour, is shown in the headpiece hereto. Some of these trips range from 40 to 400 miles in length; in fact, last winter we took an Indian hockey team, shown in Fig. 1, on a 60-day tour to many of the principal cities in Canada and the United States, covering 2984 miles. To secure this business we gladly painted in our shops the special signs which the team requested and which were placed on the sides of the coach.

Special Work in Off-Peak Period

Another new and profitable line of coach operation that has been developed in Toronto is a service to race tracks, convention halls, and the Canadian National Exhibition, which is the largest annual exposition in the world, having an attendance of about 2,000,000 vistors. To give some idea of the extent of this class of business, the Gray Coach Lines carried to this exhibition more than 75,000 passengers at 25 cents per person in the two-weeks' period. Even for prize fights held in the Royal Coliseum in Toronto we have had as many as 10 coach loads at 25 cents per passenger. As the coaches would otherwise be in the garage during

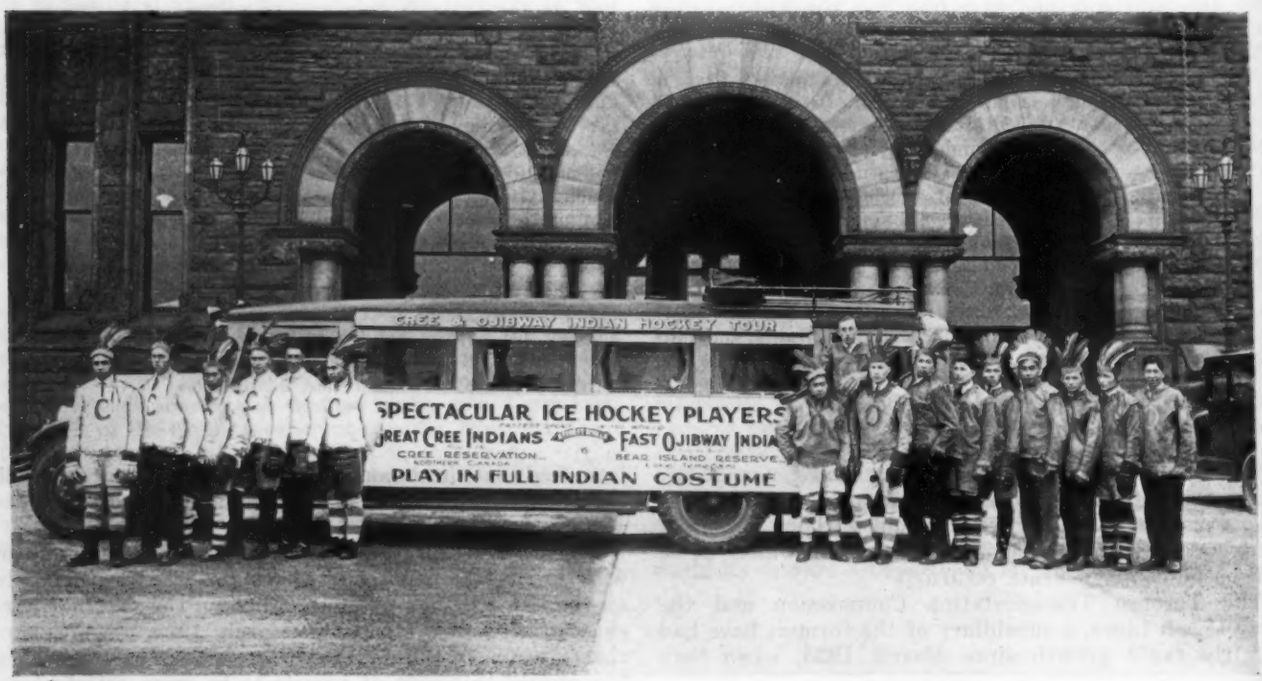


Fig. 1—A Chartered-Motorcoach Party of Cree and Ojibway Hockey Teams
This Group Toured Nearly 3000 Miles in Ontario Province and the United States by Motorcoach Last Winter

the late evening, it needs no calculation to realize that money can be made by developing this class of business.

As many operators know, money can easily be lost in interurban operation unless particular attention is paid to the smallest detail. We have added the "frills," if that word can be used, to designate the things in which we have specialized. During the winter we operate 20,000 miles per week to Buffalo, Niagara Falls, Hamilton and Brantford, which mileage is trebled in the summer. To build up this business we have had to put forward our best efforts combined with the most modern equipment. The drivers, who are specially picked men, can be relied upon to give the passenger a feeling of comfort and safety. Connections are made with other coach lines and thus considerable interline business is developed.

Terminals and comfort stations must be uptodate, and at large centers they must have the appearance of terminals and not that of stores with curb loading. Gray Coach Lines maintain six terminals and waiting-rooms fully equipped with wash-rooms. The waiting-room in the Toronto terminal is shown in Fig. 2. The personnel in these terminals is on our payroll. In addition, a score of agents in small towns and villages look after our interests on a commission basis. The main terminals have large electric signs of the Gray Coach emblem, and the agencies have a small replica of the same sign in metal.

Clerks are required to know all particulars regarding other motorcoach connections; in fact, we endeavor to supply the staff with information which will enable passengers to travel by coach over the entire North American Continent.

Time-tables should be correct, concise, and show the connections that can be made. In summer, a suitable souvenir booklet describing the routes and mentioning places of historical interest is very acceptable to the tourist.

Frills That Reduce Carrying Capacity

The salon coach is already being operated by some companies, but we would prefer to observe the type of operation before attempting to depart from the 29-passenger parlor-coach with air-cushioned seats. Many coach companies have purchased semi-salon coaches varying from 21 to 25 seats, with ice-water tanks, lavatories, and other conveniences. In some cases, however, insufficient care is taken of the frills and the object of their installation is thus defeated. It will be agreed that it is preferable to have no lavatory than to have one which is poorly maintained. It undoubtedly is possible to give additional comfort to the passenger by adding some frills, but if, in the installation of these, we drop from 29 to 25-passenger coaches, serious consideration should be given to the resulting loss in revenue by the reduced seating-capacity. In my opinion, to operate a salon coach profitably our volume of business must be sufficient to send out double-headers on the trips on which we wish to run such a type of coach, and of course a higher rate of fare would be charged on the salon coach than on the regular parlor-car. The ticket agent is then in a position to give the passenger a choice of accommodation until either coach is filled.

FIG. 2—WAITING-ROOM IN THE HEAD-OFFICE TERMINAL OF THE GRAY COACH LINES IN TORONTO

An Important Element in Attracting Passengers to an Interurban Motorcoach Line Is Modern and Attractive Terminals and Waiting-Rooms Like That Shown, Which Is One of Six Maintained by the Toronto Company

Factors That Determine Profits

In 1925, our first year of motorcoach operation, as differentiated from the "bus" feeder-services, we operated 30 vehicles. Today we operate more than 90. Our last year's revenue was 200 per cent greater than our first year's; and in estimating this year's revenue we look for an increase of 335 per cent over the first year. In this period our operating expenses have increased slightly more than 100 per cent. This is an example of what volume of business accomplishes in the lowering of costs.

After all, the characteristics of the route and the volume of business available determine the number of frills that can be afforded. Many promising companies have been ruined because they have perhaps been "freakish" rather than being content with certain "frills" which develop increased business.

THE DISCUSSION

PRESIDENT W. G. WALL[2]:—This has been a very interesting paper, and it has been enlightening in a number of respects. One of the ideas of making a success of transportation of this kind evidently is the same that we find in many other lines, that is, keeping the equipment busy; and it seems to be necessary to have the right kind of executives to do this. Some of the transportation lines in the United States are not paying well in dividends, though a few are paying better. What, in Mr. Smith's opinion is the real cause of that situation? Is it that the equipment is not kept in constant use, that we do not know what our costs are, or is it because of the type of vehicle that is being used? In other words, what are the problems he thinks most important in making a motorcoach transportation line pay?

J. L. SMITH:—One point you have mentioned is the type of equipment. Many small-scale motorcoach-operators in Canada today are buying parlor-type vehicles

[2] M.S.A.E.—Consulting engineer, Indianapolis.

for what we call ordinary street-car operation. It is more costly to operate a Pullman-type vehicle than one of the ordinary street-car type that can be bought for much less money. That in itself means cents per mile to the operator. Another point is that perhaps the operator does not try to keep his equipment looking attractive. That is most important. Business can be increased by keeping the equipment always looking A-1.

Thirdly, the driver is a main factor in getting business, and his appearance is important. Very often you have seen a driver wearing a sweater coat and an ordinary cap and smoking a cigarette. We will not keep a man like that in our service. In every case we take our man from our street-car operations, selecting young men and training them for our motorcoach operations, with the result that we get men who are satisfied, who have been in our employment a few years and are used to handling the public. For example, we select a young man who perhaps is running a street-car on the extra list, and give him a motorcoach job on a growing basis, making him a satisfied employe. It all comes back to the matter of a satisfied employe, smartly dressed, with the result that the business is increased.

Too often the small-scale operator buys too expensive a vehicle, with the result that his cost is too high; and in most cases he does not know what his costs are.

Drivers Like the Special Work

R. E. PLIMPTON[3]:—Have you had any difficulty in getting these men to change from one operation to the other? It is thought that some of the Canadian companies have considerable advantage in the way of control over their men, and that in the States it would not be possible to take a driver who was hired to operate on a scheduled route, and expects to spend his full 8 or 10 hours a day on that type of work, and change him back and forth from special work to sightseeing.

MR. SMITH:—In the first place, our drivers are satisfied because we give them a better job. When we take them on we tell them just what we shall expect of them; that if they are to operate our motorcoaches they will have to do what we want them to do. Fortunately, we do not have to do any forcing, because the men like a change from the ordinary bus feeder-route; they like to take out a special party once or twice a week. The actual driving time on special-party work is far less than the 8-hr. running on a bus route. They will probably drive for only 3 or 4 hr. in a day; the remainder of the time they spend with the party and really have a good time; so they want to go out on this work. Their earnings are much better than when they are operating on the street-car routes. Many of our drivers are salesmen for us. Only two weeks ago a driver came into my office and gave me an inquiry that he had received while taking out a special party, with the result that I got $800 worth of business by going after it.

ALBERT LODGE[4]:—What constitutes the working hours? How do you control the wages on a 13-hr. operation? Do you not have a regularly constituted day of a certain number of hours?

MR. SMITH:—Yes, the day is supposed to be 8½ hr., but we can work a man overtime, and we simply pay straight time on all special work. The men accept it, because they make extra money.

MR. LODGE:—And the men are satisfied to work under those conditions?

MR. SMITH:—Yes.

Mileage Rates on Special Service

MAJOR E. G. E. BEAUMONT[5]:—Is an average earning of $1.12 per mile special or usual? It seems to me that that is a handsome return and one that we do not often reach in England.

MR. SMITH:—We do that for probably two weeks of the exhibition period. If an operator is going to get anything out of special services, he must get plenty. For instance, sightseeing should bring $1 per mile; charter routes should bring 60 cents per mile; race-track work should bring 90 cents or $1 per mile; all the special work should bring well over 50 cents per mile.

Dual versus Single Pneumatic Tires

MAJOR BEAUMONT:—How are you getting on with the twin tires? There has been a good deal of discussion in England as to whether single or twin tires should be used. Those who held that the single tire was more likely to be successful have gradually come around to the view that the twin tire will be most effective, because there is the question of ease of handling.

MR. SMITH:—In that case, we accept the manufacturer's recommendation; but, being in the operating line, we find that the twin tire is better. We get better riding-qualities and do not find ourselves running into much difficulty. Our drivers are instructed how to change them when on the road, and so on.

MAJOR BEAUMONT:—One of our large English companies, the Midland Red Bus Co., operating from 700 to 800 motorcoaches, made an interesting experiment. It was told by the tire makers at what pressures the tires should be run and what loads they should not exceed. It occurred to the management that there might be difficulty in keeping to schedule if one of the twin tires on the rear axle gave out. So one tire on each side of a number of buses was deliberately deflated without the knowledge of the men who were working the buses; they were not told about it, and they carried on just as if the vehicles were in usual working order. The experiment was run for 5000 miles, with the whole load carried on two rear tires instead of four, and the tires stood it in every case without fail. About a dozen buses, I think, were run with deflated tires for 5000 miles, and that settled the question so far as the company was concerned.

CHAIRMAN F. C. HORNER[6]:—Did the Midland Red Bus Co. deflate the inside or the outside tires, Major Beaumont?

MAJOR BEAUMONT:—They varied it; sometimes a pair of outside and other times a pair of inside tires would be deflated; but, if the remaining tires were kept inflated to pressure, there was no indication to the driver of anything being wrong. The statement was made that the drivers did not know they were running with two tires completely deflated.

CHAIRMAN HORNER:—And they had no bearing or axle trouble?

MAJOR BEAUMONT:—I am told they had none. Those

[3] M.S.A.E.—Associate editor, *Bus Transportation*, Chicago.
[4] M.S.A.E.—Service engineer, Charles Street Garage Co., Boston.
[5] President, Institution of Automobile Engineers; motor superintendent, Anglo-American Oil Co., London, England.
[6] M.S.A.E.—Assistant to vice-president, General Motors Corporation, New York City.

figures are recorded in a paper given to the Institution of Automobile Engineers by L. G. Windhamshire, the chief engineer of that company. He gives the full statistics.

GEORGE M. GRANT[7]:—Why should there be bearing or axle trouble if only one tire on each side is inflated but equal pressures are maintained on either side of the coach? The coach will not be running on one side any more than on the other; there will be an even balance.

CHAIRMAN HORNER:—That is the reason I asked the question. They might have deflated the inside tire on the left and the outside tire on the right.

MR. GRANT:—Why would not that equalize the load?

CHAIRMAN HORNER:—It tends to bow in the weight on the inside.

MR. GRANT:—I assume they had tires equivalent to the 6-in. size, and, if that is the case, would they not get sufficient balance?

MR. SMITH:—There would be a danger in that case of touching the curb too often. If the two inside tires were deflated, they might run much longer, but if an outside tire is deflated I think it would not last more than 100 miles. We do not ask our drivers to change tires in city operation. We send out the emergency truck on a call from the driver or inspector and often change a tire in 20 min. after getting a call.

SUCCESS WITH DUAL PNEUMATICS ON TRUCKS

MR. GRANT:—In the Province of Quebec, owing to legislation, we are often forced to use pneumatic tires where we should like to use solid tires. We have construction trucks that are carrying maximum loads at all times, but, to carry that maximum load, we must put on pneumatic tires. We have bodies that are rather high, and, to lower the center of gravity, we put on dual rather than single pneumatic tires. We questioned the advisability of putting on dual pneumatics because of the crown of the roads. Three years ago we put out about 10 trucks in the Province of Quebec, operating under all kinds of road condition. Those trucks operate 6000 to 7000 miles per year. The tires are now three years old, and all of the original tires have run about 15,000 miles and are still on the 10 trucks. I assume that in England the majority of the roads are flat. We watch our tires and keep alternating them from front to rear and rear to front, so that we get a fairly even distribution of tire wear.

W. M. CLARK[8]:—Many of the Massachusetts truck operators are using dual tires on heavy equipment used on crowned roads. They found in a great many instances that the tread on the inside tire wore a great deal faster than that on the outside tire, so they are making a practice of putting their partly worn tires on the inside and putting the new tires on the outside. They find that the tread-wear equalizes a great deal more that way.

WOULD DOUBLE-HEAD INTERURBAN SERVICE

CHAIRMAN HORNER:—Regarding double-heading, Mr. Smith, did you say that you must double-head when you have a small-capacity vehicle, or that you must double-head on interurban service in any event?

MR. SMITH:—I think it is only fair to the passenger. If Pullman-type or salon coaches are to be run, their operation will cost more. The capacity is cut down to say 20 seats and, in doing that, the person who wants to ride for an ordinary fare is not given a chance unless he can be charged a fare that is not above the ordinary rate. To give all a chance to ride at the regular rate or the special rate as they prefer, the business should be built up to such a point that double-headers can be run on almost every trip, with two types of coach—the ordinary 29-passenger and the salon type.

MR. PLIMPTON:—Do you mean that you would send out two vehicles at once? Why could you not split the schedule?

MR. SMITH:—That depends on the operation. People travel at certain times during the day. In some cities the service is hourly, but we want to run only about four trips a day. It depends on the length of the trips, too.

CHAIRMAN HORNER:—That is to me a very interesting idea in motorcoach operation, that you would run two vehicles of different types in the same service.

MR. SMITH:—We have not got to that point yet, but we shall some day.

CHAIRMAN HORNER:—You advocate serious consideration of doing it when you get the traffic?

MR. SMITH:—Yes.

STREET-CAR SERVICE NOT REPLACED

CHAIRMAN HORNER:—I want to emphasize one or two statements in Mr. Smith's paper. He says, "Operation is a financial success and does not deprive the street railway of any revenue, as the majority of the passengers are former motor-car users." That is of interest, especially from the viewpoint of the electric-railway man, who might naturally be expected to think that the motorcoach will automatically take away traffic from his street-cars. You have not found that to be the case in the way you have laid out your operation?

MR. SMITH:—No, because we do not operate any city bus routes downtown; only special-fare routes, which do not follow the city car-lines; they go into an entirely new district where there are motor-car riders.

CHAIRMAN HORNER:—Will not developments bring about a condition where you will gradually replace some of your street-car lines with motorcoaches?

MR. SMITH:—Only in one case have we replaced a street-car line with buses. That is on a route about a mile in length, and the reason for doing it was that the route crosses a series of very dangerous railroad tracks, so we have not built a street-car line across them. To give better service during the night, we run a bus across to make connection between the two main car-lines.

CITY COACHES CROWDED TO CAPACITY

CHAIRMAN HORNER:—In peak hours, to what capacity do you load your street-cars?

MR. SMITH:—It depends upon the size of the equipment in use.

CHAIRMAN HORNER:—What is the seating capacity?

MR. SMITH:—About 61. We have the largest peak-hour operation in North America. We run 325 street-cars in normal operation, and 880 or 900 during the evening rush-hours. For a city of the size of Toronto, with a population of 652,000, that is enormous.

[7] Superintendent of buildings and vehicles, Bell Telephone Co. of Canada, Montreal, Que.

[8] A.S.A.E.—Superintendent of transportation, S. S. Pierce Co., Boston.

CHAIRMAN HORNER:—What is your opinion of the new type of motorcoach that seats 40 passengers and has a gross capacity of 90 to 100?

MR. SMITH:—I think that is all right, if they are operated on certain routes. If the operation is on a street-car fare and with a transfer, capacity loads can be carried; but if the coaches are to run on special work, the number should be limited to 29 in a 29-seat coach, because a special fare is charged. On city bus routes, if there are 40 seats, put in 60 or 70 passengers, because they are paying only for what they get.

CHAIRMAN HORNER:—Do you think that type of bus is going to replace the smaller-capacity street-cars and cars that are run on routes where the maximum load is in the neighborhood of 75 or 100 in peak hours, taking into consideration the congestion in the street, which is relieved to a considerable extent as soon as the street-cars are taken off?

COACHES CAN SERVE CITY OF 50,000

MR. SMITH:—No; in a city of about 200,000 people, where double-truck cars are operated which can carry 130 passengers, I should not say that these could be replaced by buses, because the congestion will be increased by having a greater number of units on the streets. If double-deck coaches are put on, the cost will be increased. In my opinion, if a bus route owned by a large corporation that runs street-cars is started in a small way and grows until it becomes necessary to operate on a short headway, that route should be operated with street-cars and not with buses.

CHAIRMAN HORNER:—The comparison could be made legitimately only with a motorcoach that is fairly nearly equal in capacity with the street-car. If you had a street-car operation in which the gross load was about 100, and you had a coach of the same capacity available, do you not think you would get better results by using the coach and taking off the street-cars, rather than operating both?

MR. SMITH:—I cannot give you a criterion, as we have nothing of the kind in Toronto; we do not believe in city bus routes.

MAJOR BEAUMONT:—I take it that, in the case of a city not already provided with street-cars, you would not advocate putting in street-car equipment, but would operate motorcoaches of a type to suit the traffic.

MR. SMITH:—Yes.

MR. PLIMPTON:—How large a city do you think could be served by motorcoaches alone?

MR. SMITH:—I should say one of 25,000 to 50,000 inhabitants, but I believe that street-cars should not be replaced by buses, which have a field of their own; if they are kept in that field they probably will make money. If an operating company starts replacing street-cars with buses without due consideration, it probably will lose money, and many other things besides. I think the larger properties are well advised, perhaps, not to do that without very careful consideration.

CHAIRMAN HORNER:—Do you agree that, if you had a coach of the necessary capacity, it would relieve congestion of the streets to use coaches instead of street-cars?

MR. SMITH:—I am not prepared to give you the costs of both, but I think that street-car operation may be cheaper, if there are several car-lines. If there is but one line, I should advocate coaches, but if there are a number of street-car lines it probably would be cheaper to run street-cars.

CHAIRMAN HORNER:—Are the university students you mentioned graduates, or on summer vacations?

MR. SMITH:—They are two and three-year men on their summer vacations. We get very good results from them.

ADVANTAGES OF INTERLINE BUSINESS

CHAIRMAN HORNER:—It is a very progressive step, it seems to me.

Another statement of interest made by Mr. Smith is that his motorcoaches are making connection with other coach lines, and that considerable interline business has developed. Probably everyone here knows of the big changes that have been made in the last year in transcontinental motorcoach operation in the United States and how the lines are connecting between various centers, getting traffic from one another and having operating companies in the metropolitan areas cooperate with them in developing traffic. I saw some figures recently from one of the motorcoach terminals in New York City. On one Sunday it sold tickets to 3500 people, including passengers on lines that went all the way to the Pacific Coast, and short-distance riders to points on Long Island and up in Westchester and Connecticut and other places. That was in one terminal in New York City in one day. It did not account for inbound passengers.

MR. SMITH:—It is very important in large cities that the motorcoach operator be able to sell tickets to any place. For instance, we have eight companies in Toronto, and it is my pet idea that we should be able to sell tickets over connecting lines. It gives the passenger confidence when he can walk into an office and ask for a ticket to a certain point and the clerk can provide the ticket. We have just put in interline tickets about three yards long giving through connections to New York City. The first day we sold six of these tickets, which we felt was very good. They read over only two lines, our own to Buffalo and the Great Lakes Stage to New York City.

We can sell tickets now in Toronto for Chicago, New York, Cleveland, Detroit, Los Angeles, and all points down the line. The rates are very attractive. After much persuasion, I was induced to give a cheaper rate for the interline business, and I am now inclined to agree with the plan, because we are building up a traffic that is all the year round. The interline traffic results from the combined efforts of the salesmen of all the other companies and is business that we would not get otherwise. We simply have an exchange; we sell their tickets and they sell our tickets, and we have no commissions. This plan is going to prove very profitable, I think. The principal advantage is that, when a passenger walks into our office and asks for a ticket, he can get it not only over our line but over any other line.

Automobile Bodies, from the Abstract Customer's Viewpoint

By O. T. KREUSSER[1]

DETROIT SECTION BODY-DIVISION PAPER — *Illustrated with* DRAWINGS

CONSTRUCTIVE criticism of automobile bodies as now built is given herein, based on experience gained in driving five-passenger sedan cars of many makes a total distance of nearly 10,000,000 miles in one year in tests at the General Motors Proving Ground. The fault finding, although humorously exaggerated, will be valuable if taken seriously, as it gives to all body designers and builders the benefit of testing experience that few companies are in a position to gain at first hand.

The author treats his subject from the viewpoint of the abstract customer; that is, the automobile-purchasing public as a whole and as represened by the imaginary average man, who is assumed to have average stature and body structure and to drive all the different makes of car. Thus he is assumed to change from one to another make frequently, instead of becoming used to only one or two cars.

Factors that influence the initial and the repeated purchase of a car are given in the order of their importance, and the index by which the customer measures the merit of the car is said to be the maximum satisfaction he has experienced with each individual characteristic in all the other cars he has driven. In other words, the best in all cars is his basis of comparison of the individual car and body, and he can be completely satisfied only if one car is as good in every respect as the best that has been found in any car for that particular feature.

Standardization of fundamental dimensions based on the measurements of the average figure of all drivers is indicated as a need of primary importance. Strictures are laid on various bodies because of interference with vision in front and through the rear window, because of squeaks and rattles and many other details that, because they are constantly evident to eye or ear, are more annoying than faults of the chassis. No attempt is made, however, to set up specifications for a body that will give complete satisfaction to various classes of user.

A COLORED man looking for a job applied to a farmer and the farmer asked him, "Are you familiar with mules?" "Boss," he replied, "I know too much about mules to be familiar with them." That is about the situation with regard to automobile bodies. We in the automobile industry have had a tremendous amount of experience; we know too much about the customer in the abstract to try to set up a specification of the satisfactory body. I shall try, however, to cover some of the viewpoints of the abstract customer —not the purchaser who is restricted to driving one or two cars, but a group of persons who drive 50 or 100 different makes of car many times a year and thus carry over from one car to another the impressions that often are so lacking if one drives a single make or two makes of car over a relatively long period.

Broadly speaking, I think it is true that bodies give less trouble in keeping the car on the road than any other major part of the automobile; but the body is forever in view and the human being can tolerate only a very few of the things that continually annoy him. He can tolerate many things on the chassis that he does not see, but something on the body that squeaks, a noisy hinge or something hanging loose or cracked or broken, constantly grates upon his nerves, and he brings the car back for service or talks about and exaggerates the defect.

We at the General Motors Proving Ground feel that bodies are still susceptible of a great deal of improvement. So is the chassis, but the body is the shell of the entire vehicle and is what the customer sees and thinks about. It is the show part of the set-up, and therefore we in the industry have to keep it shined up so as to attract the customer and keep him pleased.

A YARDSTICK FOR THE ABSTRACT CUSTOMER

To provide the background for what I call the abstract customer, who drives all the different makes of car and to whom we all attempt to sell cars, I must first tell something about the proving ground and its operation. It was established to operate test cars and get them off the highway. This has the advantage, now that we look back over 10,000,000 miles of experience, that we can run the cars about three times as effectively as we can on the public highway and therefore acquire about three times as much experience for any period of time. Another advantage is that we can set the procedure with which to test cars, as it is necessary to set up instrumentation and the facilities to get comparable results from day to day as weather and other conditions change. As an industry, we measure cars largely by what happens per 1000 miles. Unless we set up that 1000 miles with something definite—such as the same number of times to stop the car and speed it up, the same acceleration, the same hill-climb, the same mud and the same degree of adjustment and maintenance—the results do not mean anything constructive in improving the product. At the proving ground we are able to hold those different variables within certain limits, and therefore have a fairly good index of what to expect from a goup of vehicles per 1000 or 100,000 miles. We operate all the different makes of car to determine the yardstick with which the customers are going to measure our own cars. Everyone tolerates

[1]M.S.A.E. Director, General Motors Proving Ground, Milford, Mich.

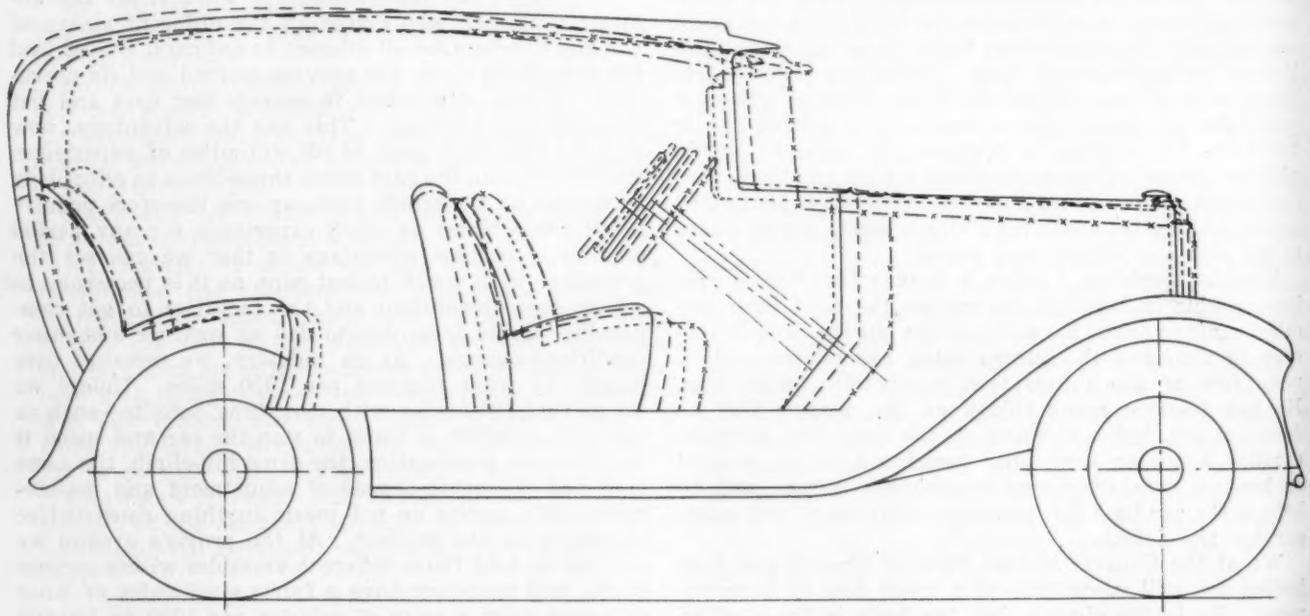
tire trouble, simply because tire touble has from the beginning been inherently a part of the operation of the automobile; but we no longer tolerate noises in the rear axle or in the engine, or loose door latches, or doors that will not stay closed. Why? Because some time, somewhere in our experience, we have had cars that had quiet axles, or doors that did stay closed, or we could actually look out of the windshield—conditions that we find are often lacking in the new cars of today in which we may be interested.

The Factors That Sell Cars

Our experience at the proving ground is exclusively with five-passenger sedans, of either two-door or four-door design, leaving out the roadsters and coupés and the more or less "tricky" cars, because the automobile business of today is largely determined by the number of sedans that can be delivered into the customers' hands. Our experience has indicated that the prospective purchaser is interested in the factors of cost, style, comfort, performance, reliability, economy and durability. It is no longer necessary to convince the prospective customer that an automobile will run, or even accelerate and climb hills. Although these features are important, he takes them for granted. We feel, from our experience in a limited way, that probably the most important things in determining sales today are features such as style and comfort that are intangible by direct measurement. No two manufacturers or designers agree fully as to style, although there is today a great deal of similarity when a particular style is shown by public approval to be a popular design. The average prospective customer of the present is attracted initially by the appearance of the vehicle. The next important factor in developing interest is comfort; and today probably comfort for the women and younger members of the family is of utmost importance. They decide whether the car to be bought is a roadster or a coupé, or a two-door or four-door sedan; and, if the car lacks style or the color is not pleasing, they do not come any closer. If it has style but lacks comfort, whether owing to the door location, poor visibility or the seat cushions, the sale is lost there. If it has both style and comfort, the next important feature of interest to the prospect is performance.

Performance is made up of those features that involve getting the car started, operating it over all sorts of roads in all kinds of weather, and eventually getting it stopped. The many difficult features of performance are readily measurable and capable of direct comparison. After performance, the next important factor in the sale of motor-cars and their repeat sales, is reliability. After reliability comes the factor of economy. Its importance varies with the price class of the car and the previous experiences of the owner. The over-all operating cost of a car—the washing, the mechanical adjustments, and gasoline, oil and tires—is an important item at some stage of ownership, be it first, second, third or fourth owner. Finally, the durability factor enters. We are able to determine the durability of different makes of car if we analyze published used-car prices, although these are often dictated by obsolescence and depreciation rather than by lack of durability. The durability factor, combined with the obsolescent style-factor, determines how much allowance the owner can get on a car when he applies it toward the purchase of a newer model that is so much better, from the purchaser's viewpoint, than the car he is trading in.

If the foregoing statements are true, we have changed from a group of engineers designing mechanical things to an engineering function of designing beautiful, comfortable cars that are mechanically right, so that they maintain the standard that has been set up before. I think most of us still turn over to the body engineer a chassis plan drawn by the chassis engineers which



Comparative Outside and Inside Body Lines of Six Designs of 1928 Model Five-Passenger Sedans

This Drawing Reveals Graphically the Lack of Standardization of Fundamental Dimensions and the Great Variation in Body Room and General Arrangement as They Affect the Driver and Passengers. The Lines Are Those of Cars Tested at the Proving Ground

shows where he can drill the holes in the frame and so on for the body, and from there on it is the body man's job to fit a body to those plans. I think we have reached the time, however, when the problem will be, and is already being, attacked the other way. The body engineer designs the esthetic and comfort features and the chassis engineers conform the mechanism to those designs. Why? Because I think there is no longer any argument that the attractive body, the comfortable body, the body that remains reasonably free from petty annoyances, largely determines the success of a particular make of automobile.

No Standard of Fundamental Dimensions

As I cannot indulge in shop talk about a specific body or a particular chassis, I shall scramble the 43 makes of American car and several times that many foreign cars in one kettle and call it the "abstract car;" and we shall be abstract customers and go shopping to find out what we can about modern automobile bodies. I shall avoid talking about color and trim combinations of the exteriors and interiors, because, as we look at the many different color combinations, we can see there is no agreement whatever among the body designers and the artists. I am going to leave out the interior fabric scheme also, and not try to determine whether the upholstery should have checks or squares or stripes, because there is no harmony or agreement; there is nothing by which we can measure that set-up except by popular appeal as measured by sales, and those are not entirely indicative of how successful the body designer has been, as so many other factors affect sales. So I shall omit the things that we can class as the esthetic and get down to the practical things we can measure and directly compare if we are going to buy a five-passenger sedan.

It makes no difference whether the car is a two-door or four-door model, we want it to carry five passengers normally; therefore the first consideration is that the car shall seat five passengers with reasonable comfort. As we are not appealing to short people or long people but to the average man, some degree of uniformity should be reached as to the amount of leg-room and head-room and whether his eyes are 4 or 8 in. lower than the top of his head, and a number of other fundamentals pertaining to the human figure. Those are definite things we should keep in mind. As we are going to put people in the car, we should at least start with the fundamentals.

Everybody has a certain width across the hips; some have more than others. While we shop around, let us measure the front seats. We shall find we can buy a car that has a beam as narrow as 36 in. and others as wide as 45¼ in. Two people are supposed to sit in the front seat in each car. The man who has been driving in the 45¼-in. front seat has a hard time to accommodate himself to a 36-in. seat, and the man who has been driving in a 36-in. seat for two passengers finds he is like a dried peanut in its shell when he is in the wide seat, particularly if the steering-wheel is crowded to one side. In different cars the width between the front door-post and the seat cushion, that is, the space through which the driver has to crawl to enter the car, will vary from 7⅞ in. to 11½ in. Steering-wheels seem to move their designed locations as different designers get hold of the car; on some cars the designer gives a 5½-in. clearance between the steering-wheel rim and the garnish rail, whereas some shave it down to 2¼ in. No wonder the driver's cuff catches on the door handle.

Head-Room and Top Hat at Odds

We find the head-room above the cushions ranges from 33¾ in. in some of the newer cars to 37 and 38 in. in some of the older-fashioned cars which are still rather popular sellers. Today's cars are becoming fairly uniform in this dimension, so we rub our head reminiscently; none of them is high enough to let us wear a silk hat unless it has a trick spring in it, or even a brown derby. The distance from the seat-back to the rim of the steering-wheel, which is another fundamental dimension, is only 12½ in. on some cars, whole on those that give more room for drivers having considerable avoirdupois it is 16½ in.; and the distance from the bottom of the wheel to the top of the seat cushion on some cars is only 5 8/10 in. while on others it is 9½ in.

The foregoing are not very wide diversions in dimensions, but when put into percentage comparing one with another they become 80, 90 and 100 per cent differences; yet the same person is supposed to sit in these various cars, for we are designing cars for the average customer.

Another fundamental dimension in a car is that on a line drawn from the pedal upward and backward so it touches the front edge of the seat cushion and extends so that it hits the back of the seat somewhere near the shoulder of the human being of average stature. This is a quick measurement that most body men use for getting the relationship between the seat-back and the position of the dash and operating devices. We find that this dimension varies from 40¾ to 46⅛ in. You may say, "That is because some cars have long wheelbases and some have short wheelbases," but the curious fact is that often the car with the short wheelbase has the longer dimension and the car with the long wheelbase is just the reverse. Obviously, each car is still built around some designer's individual belief of what a body or its dimensions should be, but the customer's viewpoint is that the dimensions should be at least as great as in the last car he had.

Driver's Line of Vision Obscured

Still another dimension that has become exceedingly important this year is the position of the driver's eye-level with respect to the horizontal obstruction of the sun visor or the upper edge of the windshield when the average man is in the driver's seat. We find that the driver's eye height averages about 26¼ in. above the seat cushion. If this dimension is correct, there are a number of cars today that have a negative vision; that is, the visor and the top of the windshield are lower than the driver's eyes. Probably everyone has got into a new car and found that he has to slump down in the seat to look through the windshield. Designers vary decidedly in details that have to do with

the comfort of the individuals who sit in the driver's seat; I have not attempted to bring in the passenger seats. Visibility from all cars has improved considerably in a horizontal direction; posts are narrower and the seat a little closer to the windshield in many instances, so that the angle of vision is wider than it used to be. But the windshield wiper is still a device costing apparently from 37 to 60 cents, whether the car costs $300 or $2,500, and invariably is placed where it cuts off about an inch of vision in an important direction.

We find that some seat cushions are so soft that the rider hits the seat slats, and others are so hard that he thinks they were made by the foundry. No two designers seem to agree as to what the seat angle should be. One tilts the occupant in a V that makes it necessary to seize handles to pull himself out, and another puts him on an incline on which he cannot stay. We find that the hardware interferes with the rider's arms and knees, and his pockets tear out when he gets out of the car. Who would try to decipher the scales on the instrument board when driving at 60 m.p.h.? Many instrument-panel assemblies apparently were designed for observation in the drafting room exclusively, as the height of the normal driver's eyes above the panel when it is installed in a car assures that the figures and graduations are completely concealed by the popular recessed indirect-lighting treatment of the panel.

Again, some windows operate with ten turns and others with half a turn; so, if a person changes from one car to another, he does not know whether the windows are up or down if he pays strict attention to his driving. The effort required to overcome friction makes many a window feel all the way up when it is not.

So much for our shopping tour. I have hit a few of the high spots to show that no standard has been established by which to measure things. Even the lowest-priced automobile is supposed to give a certain amount of comfort. Today we get a more agreeable reaction from going for a ride than we used to get. The engines are considerably smoother in operation, our roads are infinitely better, our springs better, and shock-absorbers help as a general rule, and we have greater body quietness. Drumming in a body is more objectionable than it used to be, not because bodies today drum more than formerly, in fact, we feel sure they drum much less, but the sound is accentuated and becomes extremely annoying, because, with the lessening of the other sounds, it is more noticeable.

Effect of Lack of Rigidity

Probably the first sensation observed when going for a ride in a different car is the difference in rigidity of the superstructure; that is, the entire assembly of radiator-shell, sheet-metal work and all the parts that the customer calls the body. If the various makes of five-passenger sedan, some having two doors and some four doors, are operated so as to twist them, we find no uniformity in the amount of flexibility that exists where they should be rigid. For example, roll one wheel up an incline and measure what happens to the squareness of the frame. In many cars on the market the twist in the frame between the high and the low points will be as much as 13 deg., or about 5 or 6 in. Imagine what happens to the doors when a body is twisted that way. Perhaps a driver does not often twist them that much, but if he should get in a position where it occurs it may be very necessary to have someone push the car out of the ditch, because one wheel is bearing very heavily on the wheel-housing and one rear-wheel spins so that the car has no traction. That twist is not necessarily due to a weak chassis.

Suppose one tells the body builder that the car has been twisted and the doors have locked and cannot be opened, or they are open and cannot be closed. Most body builders will say, "Well, the car builder must make a heavier chassis if he wants to put this body on it." But we find there is no relationship between the weight of the chassis and the twisting of the entire assembly. I think we all should realize that the body, with its sheet-metal work, its fenders, its splash aprons and radiator rods, and its hood, is much stiffer than even the heavy sections of the chassis.

Stiffness Not Related to Wheelbase

In measuring cars, we find that the modulus of the sections, which would be the factor developed by the depth, width and thickness of the side-rail, is a rather good index of the potential stiffness of the frame, because the designers have learned from experience that if they make a side-rail heavy they must make the cross-members more rigid. Often the cars with the highest section-modulus are the weakest torsionally and those with the lowest section-modulus are the strongest torsionally, when operated as complete cars with the doors closed. The wheelbase has very little effect, apparently, on the twist; it happens that the longer the wheelbase is the less the car twists, largely because the designer anticipated a large amount of distortion and accordingly made all the parts stiffer. The longer-wheelbase cars, being heavier and more expensive than the shorter cars, the body builders have also put more structure and strength into the upper part of the body and into the posts and their fastenings to the sill. This substantially increases the torsional stiffness of the car.

A very direct relationship exists between the torsional stiffness of a car and its freedom of annoyance to the user. A car that distorts easily or greatly gives considerable trouble with the doors because, when it it twisted, it is necessary to try to make a rectangle fit, in an oblique-angled parallelogram, which is all the more difficult to do when the latter is twisted out of its plane. The way in which many of the builders usually solve this is by leaving space enough between the door and the opening for it so that at no time can the frame twist enough to pinch the door, and filling in that space with various fabrics and weather-stripping so that the doors stay relatively free of trouble, at least while the car is on the showroom floor.

Sources of Squeaks Well Concealed

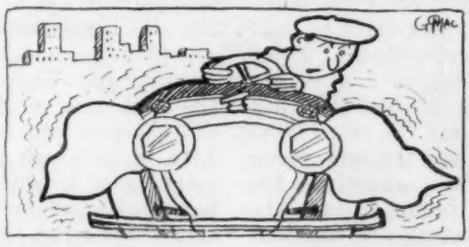
The next thing that attracts attention after the twisting is the squeaks and rattles. The annoyance they cause is also relative. It is so difficult to make a true analysis of the squeaks and rattles that we at the proving ground have decided that the place to do it is not on the road but in some sort of a twisting machine in which all the other mental reactions that a

driver gets can be cancelled out when he is trying to test for and locate the squeaks and rattles. There seems to be no direct relationship between the price of a car and its freedom from squeaks; usually it is in an inverse ratio, and the more expensive the car is, the more difficult it is to locate the squeaks.

Generally speaking, squeaks and rattles can be avoided in a new car; to keep them out after it is in use is a difficult problem. A great deal of instruction has been given on what to do to the chassis to keep it free from squeaks and from wearing out, but nobody has ever told how to keep the squeaks out of a body; and, to make matters more interesting, the builders have upholstered the bodies in such a way that even an expert cannot get to the source of the squeak to rub a little oil on it or fix it. The difficulty with our present designs, from a customer's viewpoint, is that, even though he finds where the squeak is, nobody has the heart to rip out all that is necessary to get at it to fix it. On the other hand, the chassis engineer has had to design his part of the job so that the parts can be taken apart and put together with a reasonable degree of accessibility.

The Driver's Continuous Motion Picture

Another factor noticed as one takes an initial ride in this abstract automobile is the steering rigidity. In this matter, too, there probably will be a shifting of the responsibility. If the body moves one way and the steering-wheel the other, the driver is very likely to say, "Something is not rigid." Rigidity of the front end —of the fenders and radiator—is probably more important and the problem more difficult to solve today than ever before, because, with the double kick-up and low-swung frames, high and narrow radiator, and single-piece fenders, it is hard, particularly on a rough road, to keep the front fenders from looking like the ears of an elephant when he greets a load of hay. The average driver reacts very unfavorably to this flopping around of the front end, which is very common on the abstract car we are considering. This wabble of the front end is also very bad for the head-lamp arrangement and makes it impossible to keep the lamps pointed and adjusted.



Heat from the engine still affects our comfort on long rides. In the front seats of some cars we roast in the summer and freeze in the winter, while in other cars we roast all the year round. We are still made uncomfortable by cold drafts through the floor-boards and around the door openings or the windshield; nobody looks forward with pleasant anticipation to a long drive on a cold day in the average closed car. I think that condition is going to be remedied some day. It should not be necessary to bundle up and put on double gauntlets to take a long drive. There are some cars now existent in which that is not required.

The Customer Measures by Comparison

The whole idea I want to emphasize in bringing these points out is that the customer's measure of performance in car bodies as well as in chassis is not based upon an imaginary ideal but upon direct comparison. If he has ridden in one car on a cold day and been comfortable, he has a brand-new basis of what he expects in the way of temperature control in every other car. It is the same with ventilation. At the proving ground we have a more or less fixed rule that safety requires that a closed car shall never be driven with all the windows closed. That should not be necessary, but it is. Exhaust fumes enter the car and the drivers go to sleep. We find, in general, that the higher the price of the car is, the poorer the ventilation is, because the body leaks have been stopped.

In the test cars our passengers usually are sandbags, and anyone who observes these bags toss around in the back end of a car when driving over what we call "bump roads" will have some appreciation of what the passengers would endure. Much of the testing of automobiles is done in the front seat, where the rider is over a neutral axis and is fairly comfortable. To get an indication of what happens in the rear seat, we sit in them once in a while at the proving ground, and find that the way the hardware is placed and the roof is made amounts almost to second-degree manslaughter on a bump road, in spite of the shock-absorbers. If the car hits the bumps at a frequency coinciding with the pitching period of the vehicle, it is not unusual for the seat cushions and back cushions to be thrown clear out of their recesses and, if anyone is on the seat, he will be heaved up against the top. Fortunately, the customer does not drive under those conditions ordinarily, but he does meet them occasionally. Again, we find at the proving ground that there are cars that do not respond so violently to that particular set of conditions.

Our object is not so much to find out what is wrong with a car as to determine how good a car is; therefore all cars are subjected to exactly the same type of procedure and we obtain results that are comparable. Our index is based on the best results we get with any car under a given set of conditions. We call that a bogey or par. Each car tested is compared with this. If we find one that is above it, we rub out that bogey and set up the new par.

We find that, in many cars, the cooling solution boils under certain conditions of driving. When it does so, it sputters out of the radiator cap and, if the car is driven hard, the pyroxylin enamel usually becomes spotted where the hot alcohol has taken off some of the polish. It is not unusual after a hard drive to find red rust smeared all over the hood from the rust of the engine jackets. If an attempt is made to tighten the radiator cap down, the emblem is turned at a ridiculous angle to the front. This is a condition that should not be very difficult to stop, but it is the exceptional car upon which it does not occur.

The door glasses have the habit of becoming excessively rattly on some cars when they are either all the way or part of the way down.

Even though the rest of the hardware in the car may be expensive and in good taste, the rear-view mirror invariably is mounted with a piece of 16-gage black-enamel sheet steel and the edges are still rough as the punch-press left them. Many of the rear-view mirrors will give a fair view out of the back window but do not enable the driver to see what is back of him; in other words, three-quarters of the rearward view in many

cars is blind. We are able to note that particularly, because the cars at the proving ground are running in very heavy traffic and at fairly high speeds, and often the driver is not conscious that anyone is immediately behind him on the road. Body men should, in the interest of safety, keep in mind that the driver should be able to see easily and without much movement of his eye most of the other traffic reflected in the rear-view mirror; but the size of the rear window and back light on most cars makes this impossible, so that it is possible to cut across another driver's path entirely unconscious of the fact that he is behind, because of that blind spot in many automobile bodies.

We find that the tool compartment and the seat cushion are not at all in cooperation. Did you ever try to get the tools out of the front seat of an automobile, particularly when it is raining? When one is unfortunate enough to have to jack up the car, we find that, owing to the bumpers, fenders, trunks, large-section tires, the four-wheel brakes and the low clearance, one needs to be quite a contortionist to maneuver the jack into place and jack up the car.

Despite the increased visibility and the unbroken line of vision obtained with the one-piece windshield, there are a few days in the year when we are kept from running, not by sleet on the road, but by sleet on the windshield. It is still necessary to use a razor blade to clear the windshield of ice on the modern closed cars. Probably the application of only 1 or 2 deg. of heat or the attachment of another light of glass would avoid this. Cars at the proving ground probably are run more miles in the winter than in the summer, and the only thing that stops us is sleet on the windshield; sometimes the sleet accumulates so fast that it is better to take the cars off the road than to stop them every few hundred feet and scrape the ice off the windshield.

I have not mentioned all the good points about cars, because we all know them, but I have mentioned some of the inconsistencies and shortcomings that an abstract customer experiences when driving a car; not criticising any individual car but picking out faults of many different cars used as a means of personal transportation. Whether the car costs $5,000 or $500, the fundamentals are very similar.

Condition After a Year's Operation

After a car has been run for a year, let us take a ride in it to see what has happened. We find that the squeaks and rattles are somewhat magnified and liberally multiplied, largely because, in the average car, it is so difficult to get at them. In a car that has been properly maintained and if no hesitancy has been felt in pulling off top material and prying out upholstery, the body is reasonably quiet, with certain exceptions. The rubber floor-mat, that seems to be made of tar paper, is torn and wrinkled; and, if we lift that up we find a piece of felt that looks like a camel shedding its hair. We probably find that the floor-boards are all split, some of the screws in the sills missing, others with the heads broken off and that for some reason all the floor-boards seem to be much too short although they used to fit.

Windshields invariably are loose; the windshield brackets are loose, and, if there is weather-stripping around the windshield, the rubber is shrunk and cracked and looks like anything but rubber weather-stripping after the car has had daily service for a year. We note that the instrument panel is much scratched, principally by the jiggling of the keys. I do not know why the designer should put the keyhole on the instrument panel so that the keys jangle and rub off all the finish, but that seems to be the rule. We find, also, that the tops of the cushion buttons have rather generally parted company with the rest of the button; that several of the screws in the garnish mold are broken or missing; that structural screws which often are visible inside the body and invariably are made of nickeled steel are rusted; that the window slides are frayed if they are still in place, but usually they have dropped about 6 in. from where they used to be and are frayed and sagged.

State of Upholstery and Hardware

The upholstery has a habit of coming loose over the doors and windshield and it is very difficult to put it back again, as there is nothing to tack or paste it to, and even if it is pasted it repeatedly keeps coming down. Panels in the driving compartment, which usually line the side of the compartment between the door and pedals and commonly are made of cardboard and imitation leather, are all scuffed up and wrinkled and generally dilapidated or sometimes are entirely missing. We are likely to find that the hinges are loose, the hinge screws rusty, and the latches much worn but riding in the latch case, so that if the door is opened the tongue of the latch can be wiggled back and forth probably 1/16 in. although the rest of the latch generally is in rather good condition. Most of the manufacturers use hardened steel or hard brass for latch tongues and keepers, and these do not wear very much. Usually the foot-rests are loose or torn out, and the windshield glass is all scratched by the windshield wiper. I do not know why this is so but it usually happens during a year of service, and of course the customer hates to spend $15 or $20 for a new piece of glass.

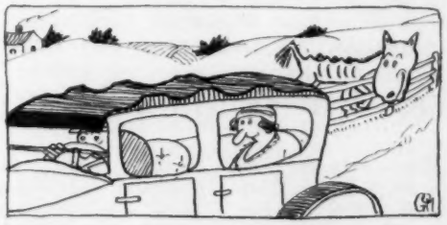
Much of the upholstery will be very spotted with oil and grease and other things, and for some reason none of the patent fluid cleaners or gasoline will remove them, although other upholstering, regardless of how old or worn it is, can always be cleaned and made to look well. If at the end of the year any of the piece of curtain cord fastened to an upholstery tack below is left, it is frayed so much that it looks like a tassel. We find that, if the seat retainer is covered with fabric to make it look nice, the fabric is all frayed out, because of the continual jamming down of the seat cushion on the cutting edge of the retainer after it is bounced out. The garnish rails with which the car is trimmed probably will be very much weather-beaten. If they are of wood they will be checked, and if of sheet metal originally finished like wood they look like sheet tin.

On the outside of the car we find that the running-boards, whether covered with rubber or linoleum, are dirty, discolored, and almost impossible to clean. It will be evident that people have walked upon the fenders on many cars, and that where there really should be running-board material the fenders are minus paint, particularly on the carriage bolts that extend through the running-board. We also find that the

finish tends to peel off of the moldings; that rust begins to show from between the moldings and body panels; that the pyroxylin enamel on the body is in good condition but the asphaltum enamel on the fenders is chalky and dusty looking. If the asphaltum enamel is scrubbed with Tripoli or other polishing compounds, it looks well again, but, in the customer's hands, the other finish on the bodies will look much better than that on the fenders. A few years ago the fender finish would outlive the body finish many times. If the wheels are finished in color it is noted at the end of the year that almost all of the color is peeled off of the wood.

How the Top Looks

As for the top, the slats are beginning to show through and can be counted like the ribs of Enoch's cow; and, if the slats are nailed on, some of the tack heads have started to come through the top material. Generally, we find that the top material is weathered more than the rest of the outside of the car. In the lower-priced car, leaks are probably developing at the end of a year of sunshine and rain, and the filler that is commonly used around the molding has begun to work loose and chip out. The nickel-plated parts are tarnished and spotted and, if they are of steel, as in the case of bumpers, the edges are rusty. The hood does not line up with the cowl or with the radiator, and probably the rivets have come clear through the hood lacing if it is made of rubber. If the lacing is fabric, the fabric is worn out, frayed and twisted on the high spots, and the hood clatters.



As we look over the body we find that probably here and there a crack has developed. Generally there is a cowl crack on each side, particularly if the radiator is well braced to the cowl; the door posts show a crack at the bottom or top of the windshield and sometimes in both places; and, if the roof is made of one piece of sheet steel, we find cracks have developed diagonally across the corners as a result of the weaving of the body. Invariably the windshield frame, if made of steel, is rusty in spots at the end of the year and looks as if it had needed a coat of paint for many months. If there is rubber stripping that is exposed, it invariably is cracked and stretched. If the headlight wires are encased in ducts, the ducts will be rusty; and, if the ducts extend through the fender or radiator shell in rubber bushings, the bushings will be found to have long since departed. Splash apron and fenders show signs of rust at the joints, and the hood-latch rivets and fastenings are also rusted.

Not all of the defects I have mentioned can be found on one car, but some of them could be found on all cars. The customer's reaction to them is negative, as it is the body that continually reminds him of the condition of the car. The chassis can have many things wrong with it, but so long as it continues to run without undue noise it does not bother the average owner; yet a cracked windshield glass or hardware that rattles too much is of more concern than an engine that is hard to start in cold weather, because it is an advertisement to everybody who rides in the car or who looks at it that the maintenance is not up to the minute. The prime purpose at the proving ground is to determine how good the cars are; therefore they are given a great deal of care and attention. Consequently, these things I have pointed out as causing negative reactions do not develop because of lack of maintenance but in spite of all the maintenance that can be given them.

Bodies Very Safe in an Upset

We have operated cars almost 10,000,000 miles, all under a single supervision, so that every mile gives a definite experience. Every now and then something goes wrong and a car is wrecked. The wrecks invariably are accidents due to drivers' negligence. In all these 10,000,000 miles of active operation, only one accident was due to failure of a mechanical feature on the automobile. This does not mean that there are not many failures of the mechanical parts, but fortunately the inspection system and the drivers by their alertness catch the potential failures before they happen. Drivers do, however, sometimes fall asleep. Our total number of accidents is relatively small; I doubt if we have one a month, and in no case has anyone been killed or permanently injured or disabled. We have learned a great deal regarding the safety of automobiles of different designs, and I think that the average closed car is about as good a box to be in, if one wants to loop the loop and roll over three or four times, as human ingenuity can devise. The present automobile, whether the body is built of steel or is of composite construction, can roll over and over without seriously injuring the driver, although the body will be badly abused and distorted. The glass is a hazard, but we have never had any drivers seriously injured by flying glass. We have wrecks in which the bodies are a total loss; but little glass is broken, and that is broken by direct contact with some exterior objects.

Height of the center of gravity in cars seems to make very little difference in their stability, as there are so many other variables that affect the stability, such as the arrangement and type of steering-gear or of the spring suspension.

As regards the effect of collision, we find that cars are stiff structures lengthwise; only a very severe lengthwise blow will be likely to really injure seriously the persons that are in them. But they are extremely frail against sideswipes and side collisions. Hence, as customers, we are fairly safe if we hit another car, but are in a rather serious predicament if another car hits us broadside. A light bump crumples up the fenders and running-boards, puts a substantial dent in the side-frame and crushes in the side of the body. The usual reaction of a driver, particularly the expert driver, when he has an accident, is like that of a pair of intoxicated men whose car smashed into another car. When a policeman came up and asked, "Who was driving this car?" they shouted triumphantly, "Neither of us; we were both in the back seat."

THE DISCUSSION

QUESTION:—At what speed are the cars driven during the tests at the proving ground?

O. T. KREUSSER:—Ordinarily, a car on a durability-

of-life test runs about 40 per cent of the time at less than 30 m.p.h.; 40 per cent of the time between 30 and 50 m.p.h., and 20 per cent at more than 50 m.p.h., or wide open; so, if the car has a speed of 70 m.p.h., it spends about 20 per cent of its time at from 60 to 70 m.p.h.

QUESTION:—How does the all-steel body compare in torsional stiffness with the steel-and-wood composite construction?

MR. KREUSSER:—There has not been enough variation in the makes of cars fitted with all-steel bodies to give sufficient information to make a proper comparison. In general, the all-steel body shows greater torsional stiffness than some composite bodies, but in some cases the reverse is true. No correct conclusion can be reached, owing to the difference in weight of cars, the wheelbase, the price and other factors that enter. I think there is more torsional stiffness in bodies, fenders and so forth than most body engineers realize; not so much in the body structure itself as in the combination including the hood, radiator and fenders. The fenders can add or deduct much torsional stiffness, depending on their shape and the way they are fastened to the frame.

QUESTION:—Is the tubular cross-member construction a big factor?

MR. KREUSSER:—Invariably a frame with tubular sections of very liberal diameter is torsionally stiff, but when that frame is assembled with a body the car may not be very stiff. Often the stiff frame, when the body is mounted on it, may show up as a completed assembly that is torsionally weaker than another in which the frame is actually torsionally weak. The body is more important than the chassis frame in providing a torsionally rigid car, assuming, of course, that the frame, body, fenders, radiator, hood and splash aprons are well anchored together.

QUESTION:—Do you notice any particular difference between steel wheels and wooden wheels as regards drumming and wind resistance?

MR. KREUSSER:—We have no definite information, only opinion, and we long since learned not to place much credence on opinion. In general, our drivers feel that a steel-disc wheel resonates or drums and sometimes accentuates noises more than does a wooden or wire wheel, but that is merely our opinion. There are many factors that might enter into that.

QUESTION:—Have you had any experience with independent wheel-suspension?

MR. KREUSSER:—No, we limit our investigations largely to current designs in production rather than testing experimental designs.

Opportunities for Trained Men in Aviation

PRACTICALLY all of the 43 aircraft manufacturers who gave information in a recent inquiry employ graduate engineers in their engineering departments. The number employed ranged from a single graduate in the smaller companies to 51 in a large company, the average number being four. But, while a technical education was deemed essential, less than 17 per cent of the graduate engineers employed had pursued specialized courses that led to a degree in aeronautical engineering.

Forty-three per cent of the manufacturers employ graduate engineers in executive positions, but in only five companies are the executives graduates in aeronautics. Yet the demand for young men of highly specialized training is apparent. Aeronautical graduates are especially needed in engineering departments where a knowledge of draftsmanship and structure is considered desirable. For positions as shop foremen, previous aircraft-manufacturing experience is the most important requisite; but for the higher positions requiring a thorough knowledge of design and stress analysis, specialized education is a necessary qualification.

Graduates in aeronautics are not, as a rule, seeking jobs. Fifty per cent of the manufacturing companies reported that aeronautical graduates had not applied to them for positions on their staffs. The others said they receive a few applications, but rarely more than one or two in a month. Conditions in the aircraft industry offer good opportunities to young men with the necessary qualifications.

PILOTS' EDUCATION AND TRAINING

Eight airport companies stated that most of their pilots are high-school and college graduates who have had aeronautical training. When these pilots were employed, they already had an average of more than 1000 hours of flying to their credit. Five hundred hours of flying-time is the minimum required of new pilots by air transport-companies. These employ an average of three pilots, though one company has as many as 29 on its payroll.

Most pilots get their training in the Army or Navy or in the Reserve Corps. The most desirable experience for pilots is a combination of Army and commercial training. Barnstorming, night, and cross-country flying in bad weather afford desirable experience to student pilots.

Positions as ground engineers and mechanics are open to a wider field of applicants. The number employed is much greater than the number of pilots. The general education of these men includes high-school training, and in some instances they are graduates of a college or a technical school. Their mechanical experience covers general and special aviation shop-work in addition to field aviation-experience. They are all licensed by the Department of Commerce except those who are helpers. The majority of the ground engineers and mechanics now employed by air transport-companies have obtained their special training in Army or Navy schools.

There is a shortage of trained men for positions as mechanics and ground engineers, but it is doubtful whether private flying and mechanic schools can furnish the necessary training because, up to this time, most of these schools are not equipped to meet the standards set by air transport-companies. Applicants are preferred who are aeronautically trained mechanics or have had experience as airplane-factory mechanics. Men are also considered for positions who have been trained as automobile mechanics or in trade schools. Training in a trade school, if thorough, is considered very desirable.—Bulletin of the Daniel Guggenheim Fund.

Automotive Research

College Automotive-Research Activities

THE term "research" as used in the title of the Research Department of the Society is, to a certain extent, an inaccurate description of its functions, for the policy pursued in establishing the department and in guiding its subsequent activity definitely prevents its operation of a laboratory. The department does not enter into the field of testing or original experimental investigation. The research work of the Society is confined to problems of fundamental and general interest, and is conducted under the technical direction of the Research Committee and by agencies selected by that body. The Research Department does assist in performing, at the instructions of the Research Committee, such executive functions as are necessary.

But if the Research Department does not carry out its own research, it is keenly interested in keeping in touch with the research work done by others in the automotive industry and in assisting in rendering this research effective. It endeavors to keep informed as to the location of facilities for research in the way of equipment, men and experience and also as to what research work is in progress.

Four purposes may be served by keeping this compendium of research information complete and up-to-date. With such data at hand, the Research Department may use its best offices to prevent duplication of facilities and effort. It can render assistance by locating the laboratory and the men best suited for any specific undertaking. Maintaining contact with sources of information makes more effective and comprehensive the Information Service of the department, which was established to handle the many inquiries that come from within and without the automotive industry. Finally, research men may be brought into contact with others who are interested in the same field as themselves or who may be attacking a different phase of the same problem.

Frequently the Research Department is called on to recommend to interested inquirers particular laboratories or research workers competent to undertake the study of some specified problem. Often, too, failing to find the required information in published technical literature, recourse must be had to first-hand sources for the results of research performed but not reported.

To meet these and other needs, the Research Department endeavors to maintain contact with investigations going forward in colleges and universities. Part of the information gathered under this heading is contained in this article; the remainder will be presented in a subsequent issue.

Colleges Canvassed by Questionnaire

Since the laboratories of technical colleges and schools occupy an important place among the research agencies of the Country, the Research Department is making a special effort to maintain contact with their activities. As a part of this general endeavor, a questionnaire was sent to about 75 colleges and universities for the purpose of eliciting information as to their research projects and their facilities and personnel. Supplementing the data thus obtained, the quarterly bulletins of the engineering section of the Association of Land-Grant Colleges and Universities, reporting the engineering research at about 30 institutions, are kept on file and frequently consulted.

In this and a subsequent article to be published in this section of THE JOURNAL, information on college research that has been gathered by the Research Department will be summarized. Only projects bearing on the numerous phases of the automotive field, such as raw materials, design, production, operation, maintenance and service, will be included. Emphasis will be laid on the nature of the problems that are being or recently have been studied rather than on the results obtained. It would be impossible within the compass of a few pages adequately and accurately to detail the findings of the large number of investigations. The purpose is, rather, to show the type of equipment and the personnel experience available at colleges, and to indicate where those interested in any particular problem may find further information on it.

Grouped according to subject matter, the investigations referred to fall into seven divisions, dealing with (*a*) engines; (*b*) petroleum and its products, covering automotive fuel and its use, lubricants and lubrication; (*c*) chassis parts; (*d*) highways and the inter-relation between them and automotive vehicles; (*e*) aeronautics; (*f*) metals; and (*g*) miscellaneous.

Engine Problems Studied

In the field of engine research, four projects dealing with engines in general or with specific types of engine may be noted. Rutgers University, New Brunswick, N. J., has completed a study of ideal gas-engine cycles designed to make readily available the data for a theoretical cycle as a criterion of performance for actual engines. In this study, a method was developed that is said to be almost as easy of application as the Mollier Chart for steam engines, and that shows that

the results obtained from an average gas mixture are applicable with a very small error to the range of mixtures used in practice. A comparison of the constant-clearance with the constant-compression engine, using the Jacklin variable-compression engine, is a project on which some work has been done and further investigation is contemplated at Purdue University, Lafayette, Ind.

That the awakening of interest in Diesel engines has been shared by colleges is indicated by two research projects dealing with this type of powerplant. At the Carnegie Institute of Technology, Pittsburgh, an experimental solid-injection, high-compression engine was designed and built and considerable research work has been done on it. The Pennsylvania State College, State College, Pa., has under way an extensive investigation into oil-sprays in solid-injection Diesel engines. This research is under the general direction of Prof. F. G. Hechler, director of the Engineering Experiment Station, and the work is being done by Prof. P. H. Schweitzer and Assistant Professor Thulin. The specially designed equipment includes a large chamber with windows, a source of illumination, and window wipers. Various types of spray nozzle and solid-injection sprays are being studied, and the effect of variation of the air pressure in the chamber is also observed. Penetration and impact of the spray and the pressure at the nozzles can all be measured by the instruments provided.

Electrical Equipment and Carburetion

Of specific engine parts to be studied, the electrical equipment and carbureting devices have attracted most attention. The State University of Iowa, Iowa City, Iowa, has conducted research on spark intensifiers for the ignition of internal-combustion engines, Arthur H. Ford, professor of electrical engineering and inventor of the Roadlighter head-lamp lens, being the investigator. Sparking voltages and their relation to electrical pressure, the character of electrodes, gap length, and the nature of the gas are some of the subjects of study at the University of Michigan, Ann Arbor, Mich., where the work is being done under the direction of O. S. Duffendach, assistant professor of physics, who has published a number of papers on problems related to the conduction of electricity through gases. Another investigation carried on by this university that may be grouped in this class is the study of the reproductibility and constancy of the electromotive force of voltaic cells of the type of the lead storage-cell.

One of the past projects of the Carnegie Institute of Technology was the study of a self-cleaning spark-plug in which the current runs over porcelain instead of jumping an ordinary air-gap, making a forked discharge and burning away carbon and dirt on the porcelain. The wire at the bottom of the plug is flush with the porcelain. Records of tests on these plugs are available to those interested.

Of the colleges studying carbureters, Purdue University has gone into the subject most extensively, and the automotive industry in general is familar with the published bulletins covering this continuous research program. The work now in progress includes studies of the flow of fluids through jets, studies of supercharging, and a continuation of the commercial carbureter tests previously reported[1]. Some investigation has been made in the course of thesis and graduate work of the effect of change of temperature of the inlet air and mixture on power, exhaust-valve and exhaust-gas temperatures. An extensive group of equipment has been accumulated at Purdue University for this and other test work. It includes dynamometers, a carbureter test-plant, two types of air-meter, a Jacklin high-speed multi-cylinder-engine indicator, a manograph, four engines, two types of fuel meter, a fan brake and a water brake, and such instruments as tachometers, stop-watches, counters, electric meters, scales and microscopes.

Carnegie Institute recently completed a study of the characteristics of several commercial carbureters under various adjustments and conditions, using an air box provided with rounded orifices for measuring air-flow. Both block tests and road trials are being made at the Oregon State College, Corvallis, Ore., in attempting to find improvements in methods of carbureter adjustment.

Allied with the study of carburetion, but inclusive of other phases of engine operation, is the work going on at the University of Arkansas, Fayetteville, Ark. Here is being determined the evenness of fuel distribution among the cylinders of a standard automotive engine, using a stock carbureter and manifold.

Findings favorable to steam-cooling were the results of experiments carried out at Princeton University, Princeton, N. J., with a system in which water enters the water-jackets at the bottom of the cylinders, passes through them and emerges as steam into the radiator, where it is condensed. The experiments were conducted by Alfred H. Marshall, graduate student, under the direction of Prof. Edward P. Clover, of the engineering faculty.

One other investigation that may be mentioned in connection with studies of engine parts is the determination of the effect of the size and length of the exhaust pipe on the power of an engine and the economy of its operation. This is a project of the University of Maine, Orono, Me., carried out by means of a series of laboratory tests.

Engine Performance and Combustion Processes

Interest in engine performance, aside from combustion processes, is made evident by two studies: a graduate thesis on engine friction-losses, by a Purdue University student, and research on automobile-engine vibration at the State College of Washington, Pullman, Wash. Plans for the latter embrace a comparison of engine types to determine the cause and nature of vibration.

The latter university has also interested itself in a project related to combustion processes; i.e., the design and construction of a high-speed indicator for automotive engines.

Flame propagation in closed cylinders was the subject at Cornell University, Ithaca, N. Y., of an investigation the results of which have been embodied in a bulletin written by G. R. McCormick, G. B. Upton, A. C. Davis and H. Diederichs and issued by the engineering experiment station there[2]. Prof. D. S. Chamberlin, of the department of chemistry and chemical engineering, Lehigh University, Bethlehem, Pa., has done some work along the same lines, having studied flame transmission

[1] See Purdue University Engineering Experiment Bulletin No. 21.
[2] See Cornell University Engineering Experiment Station Bulletin No. 8.

and flame speed with a complete equipment of tubes, camera and instruments assembled for the purpose.

This section dealing with engine design and performance may be brought to a close by a reference to the investigation of the effect of moisture on compression in internal-combustion engines which is being made at the Michigan State College, East Lansing, Mich. The equipment for the experimental work includes an electric dynamometer equipped with an electric tachometer, magnetic control of the speed counter, and an accurate fuel-weighing device.

Fuel Production and Use

Of the subjects falling into the second division—petroleum and its products, including automotive fuel and its uses, lubricants and lubrication—it is appropriate to consider first the characteristics of fuels in relation to engine performance. The problem of detonation, which is in the forefront of current interest, is receiving attention in a number of university research departments. In the investigation of cylinder knocks and methods of preventing them, conducted at the University of Iowa, H. L. Olin, associate professor of chemical engineering, and his assistants concentrate particularly on the effect of metallic colloids and the anti-detonating characteristics of cracked low-temperature tars. Furfural is the antiknock material engaging the attention of E. B. Smith and O. R. Sweeney at Iowa State College, Ames, Iowa, their aim being to determine by laboratory and road tests the extent to which this substance will reduce or prevent detonation when used as an admixture to the gasoline fuel.

Considerable material has already been published[3] on the program of investigation carried out by George Granger Brown, professor of chemical engineering, University of Michigan, and director of research for the Association of Natural Gasoline Manufacturers, Tulsa, Okla. This has for its subject the relation of motor-fuel characteristics to engine performance, with particular reference to the value of natural gasoline as a component of motor fuel. Volatility, vapor pressure and antiknock qualities are the phases receiving major consideration. Special equipment developed to facilitate the finding of accurate results includes volatility apparatus for making equilibrium-air distillations from —50 deg. fahr. up; fractionating columns for preparing pure compounds from motor fuel and gases, and for analyzing gasolines and crudes; vapor-pressure apparatus; refrigerating equipment for low-temperature work and for storing samples; small antiknock test-engine with dynamometer; small engine for determining oil dilution and carbon formation; and an engine laboratory equipped with typical motors and electric dynamometer, with special arrangements for making acceleration as well as standard tests.

In addition to the foregoing research, Professor Brown has also directed an investigation into the mechanism of gaseous combustion and detonation and the effect of "dopes" on the combustion of different fuels[4]. A small bomb for exploding gaseous and liquid fuels under different conditions of temperature, pressure and gas composition was one of the pieces of apparatus used in this research. It was equipped to measure the pressure rise during combustion, the rate of rise of pressure and the products of combustion. A long bomb was also used. This was equipped with a number of pressure indicators and a window, so that the progress of flame and pressure rise could be recorded on photographic films.

Performance of Gasolines Compared

Another noteworthy fuel-performance study organized at the University of Michigan is that directed by Prof. W. E. Lay. In this research a Ricardo variable-compression engine constitutes the principal piece of apparatus, and typical current commercial fuels are being compared with one another and with a standard fuel used by Ricardo and others. The universal test-engine is very flexible; its compression ratio may be varied from 3 to 16 to 1 without dismantling it, stopping it or altering any condition of test, and its carbureter equipment is such that instantaneous changes can be made from one fuel to another without any other change in operation. Devices for regulating and measuring the cooling water in the jackets and the air and fuel entering the carbureter are provided. The water-jacket surrounding the combustion chamber is separate from that of the cylinder-wall, so that the friction of the piston may be maintained by a constant cylinder-wall temperature, while the effects of combustion-chamber temperature can be observed by changing the temperature of the cooling jacket for the combustion chamber.

The Colorado School of Mines, Golden, Colo., is studying the blending of fuels from Colorado coals with fuels from different petroleums, from the viewpoint of detonation, combustion and corrosion. R. C. Beckstrom, professor of petroleum engineering; Roscoe W. Morton, assistant professor of mechanical engineering; and L. W. Hartkemeier, assistant professor of chemistry, are engaged in this research.

Four other projects may be mentioned as belonging in this general category: a study of the ultra-violet spectroscopy of engine-fuel flames by G. L. Clark, divisional director, Research Laboratory of Applied Chemistry, and A. L. Henne, fellow of the Chemical Research Board Foundation, at the Massachusetts Institute of Technology, Cambridge, Mass.; experimental and thermodynamic studies of the thermal decomposition of methane and benzol, by Prof. R. C. Cantelo, of Lehigh University; and an investigation by Prof. E. S. Sinkinson, of the same institution, with the object of improving the character of fuel. In the last-mentioned research, tests were made at various speeds and compression pressures and with several types of cylinder lubricant. The last two investigations were completed several years ago but are of current interest, since the equipment with which they were carried out is still available for use.

Phases of Petroleum Production

Problems in connection with the production of petroleum occupy a large part in the research program of the Colorado School of Mines. One of the projects listed in answer to the Society's questionnaire had for its subject the possibility of increasing the recovery of oil by flooding oil sands with alkaline solutions; another

[3] See *Oil and Gas Journal*, June 10, 1926, p. 120; *National Petroleum News*, June 9, 1926, p. 45, and Nov. 17, 1928, p. 28; *Industrial and Engineering Chemistry*, July, 1926, p. 718; *Refiner and Natural Gasoline Manufacturer*, December, 1926, p. 30; and Bulletin of the American Petroleum Institute, December, 1926, p. 161.

[4] See University of Michigan Bulletin No. 7; *Industrial and Engineering Chemistry*, April, 1925, p. 397; December, 1925, p. 1229; February, 1927, p. 280; March, 1927, pp. 363 and 366; and *National Petroleum News*, February 9, 1927, p. 88.

project dealt with the effect of pressure on the migration and accumulation of petroleum.

With semi-industrial apparatus for the oxidation and the subsequent operations of distillation and thermal decomposition, the Carnegie Institute of Technology has studied the production of acids and motor fuel from petroleums by vapor-phase catalytic oxidation. The University of Kansas, Lawrence, Kan., lists as one of its subjects of study the utilization of natural gas with special reference to condensation into oils.

Two related investigations are Project No. 13, of the University of Tennessee, Knoxville, Tenn., entitled The Low-Temperature Carbonization of Some Tennessee Coals, and a study of the low-temperature distillation of coal, which involves the development of a process utilizing a rotary retort, at the Michigan State College, East Lansing, Mich. In the former research the purpose is to determine the character of the coke and the composition of the oils produced, and the equipment consists of small retorts of laboratory size, both internal and external heating having been tried.

The Michigan State College is also interested in oil cracking, gas enriching, the extraction of oil from shale, and similar topics.

A brief enumeration of some studies made at the West Virginia University, Morgantown, W. Va., will complete the summary of collegiate research on petroleum production. C. R. Jones, dean of that institution, in discussing the projects undertaken, writes in part:

> Some of the research work done in the department of chemical engineering is probably of interest to your Society. For example, one large gasoline corporation maintained a research fellowship here for the purpose of developing an absorbent gel other than the silica gel and activated carbons. As a result of the work done here, a new absorbent gel was discovered which is of considerable commercial value. The fellowship was continued in order to have a study made of fractionation of casing-head gasoline, which resulted in some valuable information.
>
> Another investigation which was carried on for some time was Project No. 13, Distillation Products of West Virginia Shales and Cannel Coals, by Prof. W. W. Hodge, L. P. Foley and others. Some very interesting results were obtained from the cannel coals, but the shales proved to be too lean to be of commercial value.

Lubricants and Lubrication

As in the case of fuels, the research on lubricants may be considered under two headings: usage and production. Two projects of the former type have recently been under way at the Pennsylvania State College. The first is an investigation of journal performance and has for its purpose to check experimentally the performance of perfectly lubricated complete bearings predicted by the charts developed by H. A. S. Howarth.

A machine designed by the Kingsbury Machine Co. has been loaned to the Pennsylvania State College for this investigation. It consists of a test bearing 2½ in. in diameter by 4½ in. long. It is babbitt-lined and is supplied with only a circumferential groove placed near one end. The shell of this bearing is cylindrical and is carried in a heavy housing through which the load is applied. The shaft is supported in self-aligning bearings. Oil under a pressure of about 10 lb. per sq. in. is supplied at the end of the bearing opposite the circumferential groove. The shell is floated in the housing by a second supply of oil under high pressure, thus reducing the friction between the shell and housing to zero, when the relative velocity of the two is zero. Oil-film pressures may be measured at four zones spaced equally along the axis of the bearing. Shaft displacements with respect to the bearing may also be measured at the extremities of the two diameters at 90 deg. to each other, near one end of the bearing. Two thermometer wells are provided in the shell for obtaining the temperature of the bearing.

To investigate methods of determining oil-film temperatures is the object of the second investigation undertaken by the Pennsylvania State College. The experimental observations are made on a shaft supported in two plain bearings and carrying a plain split cast-iron bearing, fitted so as to give a rather large clearance. Little or no load is applied, the temperature being due to the internal friction of the fluid. The temperature is measured by various arrangements of thermocouples and is compared with those shown by mercury thermometers placed in wells in the shell.

An extensive research having for its purpose the development of lubricated bearings to withstand very heavy unit pressures at low and moderate rubbing speeds has been conducted at the Carnegie Institute of Technology.

The equipment used in this investigation and still available includes bearings and apparatus suitable for pressures up to 3100 lb. per sq. in., and apparatus for determining the viscosity of oil, the coefficient of friction, and the compressive strength, hardness and shock resistance of bearing metal.

Lubrication Value of Oils

In its research on the lubricating value of oils, the University of Michigan has developed a method for the measurement of adhesion tension of a liquid against a solid. It is felt that valuable information on the lubricating value of oils can be obtained by such measurements made with the special equipment designed. Another project on the general subject of oil-testing is under way at the State College of Washington. Here a new type of viscometer has been developed and constructed. The West Virginia University may also be regarded as a contributor in this field, having assisted in determining the best lubricating oils for use in trucks operated by the State.

What happens to oil in usage is a subject that continues to interest automotive engineers, who will be glad to follow the results of an investigation made at the State College of Washington to throw light on this point.

Under the heading of oil production may be noted two projects dealing with the determination of practical methods of restoring the lubricating values of oils used in the crankcases of automobiles, tractors and gas engines. One is the undertaking of the Colorado School of Mines; the other, of the Kansas State Agricultural College, Manhattan, Kan.

Charles M. Manly Memorial Award

Medal to Be Awarded Annually for the Best Paper on Aircraft Powerplants Presented to the Society

THE work of the late Charles Matthews Manly in the fields of automotive and aeronautical engineering needs no advertisement among his fellows in these professions. His contributions enriched many fields, and his share in their development will be long remembered.

Leading members of the Society have felt it to be appropriate that steps should be taken to secure a definite engineering memorial to Mr. Manly to keep the memory of his life and work fresh before automotive engineers of the future as an inspiration to them. With this end in view, Past-President John H. Hunt, shortly before the conclusion of his term of office in the Society, appointed Edward P. Warner, David Beecroft, Henry M. Crane, and C. B. Veal as the members of a committee to consider the form of a memorial and make recommendations to the Council.

This Committee, feeling that no commemorative form could be more appropriate than one which would afford direct incentive to original work in a field in which Mr. Manly had wrought marvels in its pioneering days and in the days of his own youth, recommended the establishing of a Manly Memorial Medal, to be awarded annually for the best paper presented to the Society or any Section upon a subject related to the theory or practice of the design or construction of aeronautic powerplants. The Council approved the recommendation, and the Manly Memorial Medal is to be created.

Rules for Award of the Medal

Following the recommendation of the Council, and with its approval, the Manly Memorial Committee adopted the following rules for the award of the medal:

The Manly Memorial Medal shall be awarded to the author of the best paper relating to the design or construction of, or research on, aeronautical powerplants or their parts or accessories, to be presented at a meeting of the Society or any of its Sections during the calendar year.

All papers on the subjects mentioned which are presented before a Society or Section meeting will automatically receive consideration by the judges.

The award shall be made by three judges appointed by the Council, each judge serving for a term of three years and the term of one judge expiring each year.

The members of the committee of judges shall not be eligible in the competition.

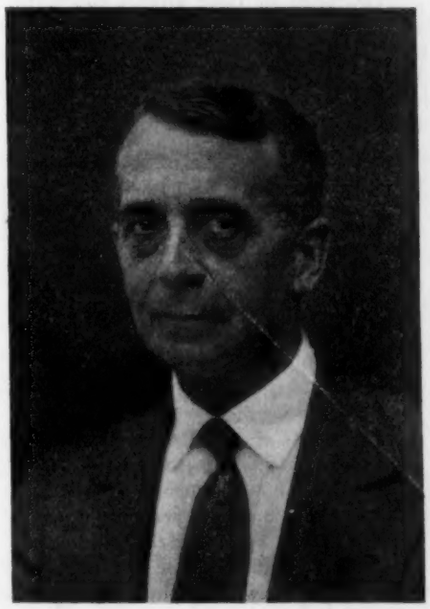
No one person shall win the medal twice within any period of four consecutive years: that is, three years must elapse after award of the medal to a given person before he is again eligible.

Papers presented at Society and Section meetings shall be judged primarily for their value as new contributions to existing knowledge of the aeronautical art. Judgement shall be based upon the value of the paper itself as such an original contribution, not upon the value of some mechanical development or invention already known which the paper may describe.

The first award under these rules shall be made for the calendar year 1928.

An Airplane Powerplant Pioneer

A brief reference to some of the early pages of aeronautic history will indicate the fitness of having a memorial to Mr. Manly take such form as will encourage progress in the development of aeronautic powerplants.



Charles M. Manly

Just 30 years ago, Samuel Pierpoint Langley was confronted with the necessity of procuring a suitable engine for a flying-machine. His quest was urgent, his incentive an invitation from President McKinley to develop a flying-machine capable of being used in warfare. A contract was made for the delivery of a 12-hp. engine, to weigh not more than 100 lb., but this contract was never completed.

It remained for Mr. Manly to design for Dr. Langley's "aerodrome," as he called it, the first successful internal-combustion aircraft engine. This, a five-cylinder radial engine, interrupted the development in the vertical type and indicated the possibilities of other cylinder arrangements. The scheme of ignition and the design of the spark-plugs were originated by Mr. Manly. The connecting-rod layout which he worked out has been the pattern on which all later models of this type of engine have been formed. Most remarkable of all, although no manufacturer had been able previously to construct an engine weighing less than 12 lb. per hp., Mr. Manly's engine weighed only 2.4 lb. per hp., a weight-power ratio not met subsequently until the building of the 400-hp. Liberty-12 engine.

Provision for Medal Fund

Mr. Manly followed up this brilliant achievement of his early career with many other accomplishments of equal importance, showing always a comprehensive knowledge of all phases of automotive and aeronautic engineering and an ability to analyze keenly and accurately new conditions and problems.

His mental endowments were always at the service of this Society. He was President of the Society in 1919, and during his administration laid the foundation for the Operation and Maintenance movement of the Society. He devoted much effort toward making effective its standards work, both as a member of the various divisions of the Standards Committee, and as its Vice-Chairman. He presided at many meetings of the Standards Committee. He represented the Society in aeronautic standardization activities both in this Country and abroad during the World War, and contributed signally to the value of the work of the Patents Committee and the Standardization Policy Committee. He was a representative and the principal spokesman of the Society on the American Engineering Standards Committee. To honor his name is to liquidate, in some small measure, a debt of gratitude as well as to pay a tribute to a great engineer and inspire posterity by showing forth his achievements.

Feeling that the Society as a whole is eager to participate in providing the suggested memorial award, the Committee in charge has arranged to send to every member an invitation to join in raising the fund of $7,500 necessary to make possible its establishment.

Society Reorganization Proposed

Establishment of Seven Professional Divisions Suggested, with Executive Heads Recognized as Vice-Presidents and Councilors

SHALL the Society be reorganized into professional "Divisions"? This question is put directly up to the membership for consideration and an expression of opinion as the result of conclusions reached by members of the Reorganization Committee at a meeting held in Detroit on Sept. 5. These conclusions are set forth in the accompanying box. They mark the first definite step taken in what has been stated to be the most important project ever undertaken by the Society.

Briefly, the proposal is that seven Divisions representing the professional interests of the members be organized within the Society; that these Divisions report direct to the Council, but that they be self-governing through nomination of their heads by members directly interested in the activities of the respective Divisions, the Division heads to be elected by the entire voting membership; and that these heads shall automatically become Vice-Presidents of the Society and members of the Council.

Divisions which the Committee members believe should be recognized are:

Motor-Vehicle
Aeronautic
Production
Tractor and Industrial Engine
Motorboat
Body
Operation, Maintenance and Service

Members of the Committee present at the Detroit meeting were: Chairman F. E. Moskovics, V. G. Apple, F. F. Chandler, C. F. Clarkson, W. T. Fishleigh, J. H. Hunt, Vice-President W. R. Strickland, and President W. G. Wall.

Opinions of Members Wanted

Although the conclusions reached at this meeting have not been confirmed by the entire Committee, it is believed that the fundamental ideas will be so approved and that every student of Society activities also will approve them. The exact form of reorganization will be determined upon, however, only after careful study of all the opinions expressed. With this in mind, the Committee directed that the conclusions be published in full in the October issue of THE JOURNAL, accompanied by a request that every member interested in the problems involved submit his views thereon in writing to the Society. It is expected that the Committee will hold several meetings to discuss the project before a complete plan is evolved that will meet all the various requirements.

The Committee's conclusions represent the initial step in a study which should result in greatly increased activity in every professional field that comes within the scope of the Society's work.

Fig. 1 is a chart of the organization, as proposed by members of the Reorganization Committee, based on the conclusions given in the center column.

Conclusions Reached by Committee

(1) All professional activities should be controlled by those directly concerned.

(2) The President of the Society should be elected.

(3) There should be no non-working, honorary, titular Vice-Presidents.

(4) Special professional Divisions should be recognized.

(5) The number and kind of divisions should be decided by the Council and the names incorporated in the By-Laws.

(6) Until a group can establish a Division in at least one Section and can assure the Council that it can function successfully on a National basis, it will not be recognized as a Division of the Society.

(7) The heads of the Divisions should be Vice-Presidents of the Society and members of the Council.

(8) The heads and vice-heads of a Division should be elected by the Society from nominations made by the Division nominating committees.

(9) The two surviving Past-Presidents who last held office should be members of the Council.

(10) There should be six Councilors at Large, three to be nominated and elected each year for a two-year term, the Nominating Committee to be appointed as at present.

(11) In case of the death or disability of the President, the Council should elect his successor from their number for the unexpired term.

(12) Divisions recognized are, Motor-Vehicle; Aeronautical; Production; Tractor and Industrial Engine; Motorboat; Body; and Operation, Maintenance and Service.

The object which it is desired to accomplish by the changes proposed, which will require complete revision of the Constitution of the Society, is to give the members interested primarily in each field of professional activity full opportunity to initiate and direct the activities of the Society in these branches and to place the responsibility for such activities on men chosen by the members within the various groups.

History of Proposed Reorganization

The history of the proposed reorganization dates from the 1926 Annual Business Meeting, at which J. F. Winchester proposed that:

The office of Second Vice-President Representing Stationary Internal-Combustion Engineering be abolished and that of a Second Vice-President Representing Operation and Maintenance Engineering be created in its stead.

At the Business Session of the 1926 Summer Meeting, Mr. Winchester withdrew his amendment with the understanding that further study would be made of the situation. Such further study resulted in the submission of three additional suggestions, as follows:

(1) H. M. Crane proposed abolishing the Second Vice-Presidencies, substituting Second and Third Vice-Presidents, the addition of four Councilors, and the passing of a By-law recognizing the divisions of the Society activities.

(2) The late Charles M. Manly proposed that the present Second Vice-Presidencies be retained and that committees be established for Design, Production, and Operation.

(3) F. F. Chandler proposed that the Second Vice-Presidents be appointed by the Council, instead of being elected, and that the number of Second Vice-Presidents and the Divisions they represent be decided by a majority vote of the Council. Under this plan the Second Vice-Presidents would not necessarily be members of the Council, which could appoint men who were not Councilors.

A suggestion was made at the Business Session of the 1927 Annual Meeting that the foregoing proposals be submitted to the Sections. This was done and as a result the Crane proposal was approved by the Governing Board of the Pennsylvania Section, and the Winchester proposal by the Governing Boards of the New England and the Northern California Sections.

Membership Analyzed

Prior to the Summer Meeting this year, the subject was reviewed by President Wall, who later called a general conference at Quebec. This was attended by V. G. Apple, Earle Buckingham, F. F. Chandler, J. C. Chase, H. M. Crane, W. W. Davis, Sidney R. Dresser, Walter Fishleigh, F. C. Horner, Albert Lodge, F. E. Moskovics, N. B. Pope, Norman G. Shidle, and Col. W. G. Wall.

Complete analysis had been made of the Society membership according to the nature of work in which the members are engaged and to the branches of the industry to which their activities are devoted. Charts in Fig. 2 and 3, based on this analysis, constituted the most interesting part of the analysis.

The consensus of opinion at this conference was that professional activities within the Society should be furthered in every possible way. Walter T. Fishleigh offered a resolution, which was passed, that a committee be appointed to study the subject and propose a definite plan for reorganization. It was understood that the members of the Constitution Committee would follow the work of this special committee closely, to be in position to act on changes in the Constitution that presumably would be necessary.

Acting upon the Fishleigh resolution, President Wall appointed a committee of 18 members, under the chairmanship of F. E. Moskovics, Chairman of the Constitution Committee. Other members of this Committee are: V. G. Apple, W. L. Batt, E. P. Blanchard, F. F. Chandler, J. C. Chase, C. F. Clarkson, Howard E. Coffin, H. M. Crane, W. T. Fishleigh, J. H. Hunt, C. F. Kettering, R. E. Plimpton, N. G. Shidle, W. R. Strickland, W. G. Wall, Edward P. Warner and J. F. Winchester.

Intense interest in the work of this Committee has been made evident by several letters received by Chairman Moskovics from members of the Committee who could not attend the Sept. 5 meeting and from others. Each letter indicates that much time has been spent in study of the present organization of the Society and of the way in which it has functioned.

At the September meeting of the Committee, Mr. Fishleigh submitted for consideration an organization chart, based on the divisional organization of the Detroit Section, which he felt should receive serious consideration. This plan is similar to that of the organization of the General Motors Corp. in which the president of a division is a vice-president of the corporation. The conclusions reached were largely based on this proposal, fhich is similar, in regard to Council organization, to the Chandler proposal.

Feeling of Members Summarized

W. L. Batt, Chairman of the Finance Committee, and a member of the Reorganization Committee, writing Chairman Moskovics just before leaving on a European trip which prevented him from attending the Reorganization Committee meeting, summarized the feeling of a large number of members when he wrote in part:

It seems to be highly essential that the Society shall definitely lay down a policy for the development of professional division activities, because it is in this direction that the greatest opportunity for permanent growth is apt to lie. As one looks back over the past history of the various technical societies, I believe he can only conclude that those things of permanent value and those accomplishments which are remembered are the result of particularly intensified technical activity in specific directions.

I believe that such reorganization as is necessary specifically to provide for the active recognition of professional division activities should be brought about. The heads of these divisions will need to be men of standing in their respective lines. Their committees must be working committees, not mere decorations. I strongly favor the practice of a continuing standing committee, through which this can be carried out.

Properly selected and intelligently encouraged, these committees should do much more toward the production of papers and meetings of merit than the office can ever be expected to do.

It seems to me that the problem of our Society is somewhat different today than it was formerly. A wonderful work was accomplished when the S.A.E. standardization activity was put through. With nothing else to its record, the Society would live for a good while on this accomplishment. We have got to try to find some new problem

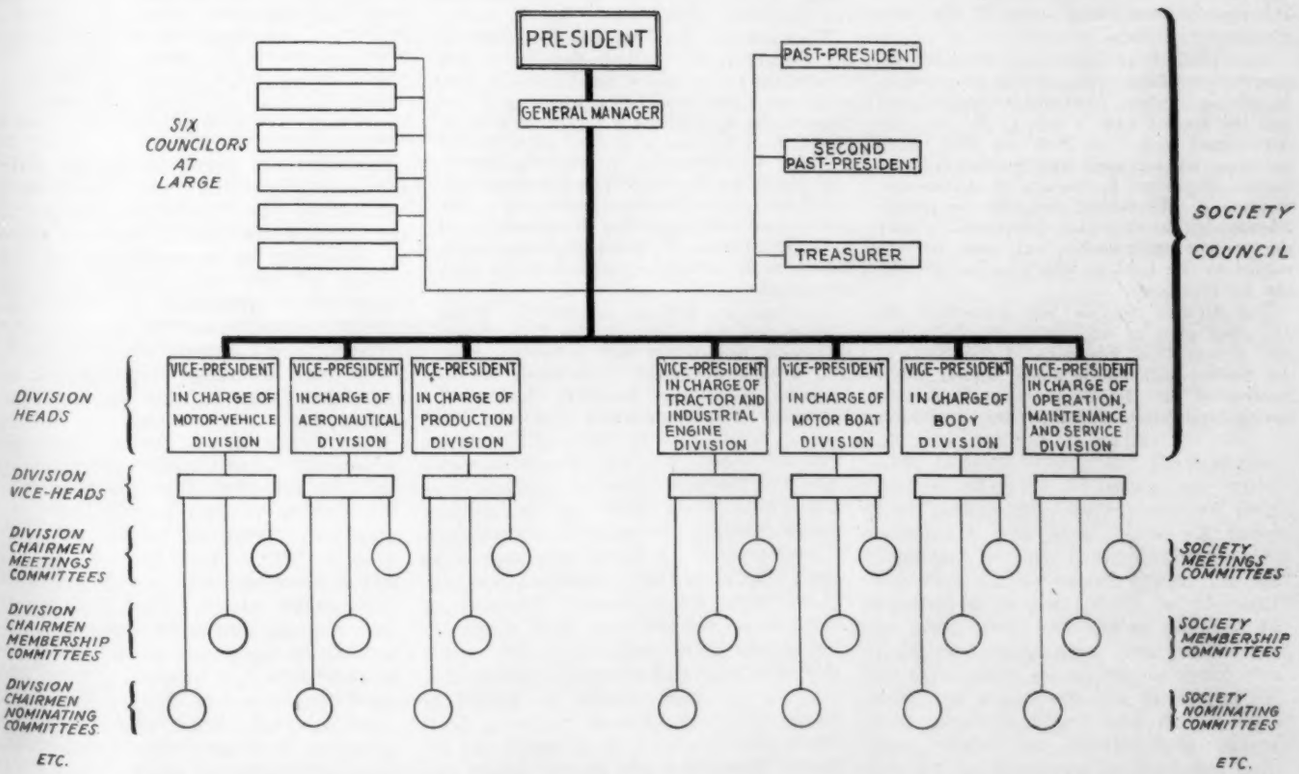
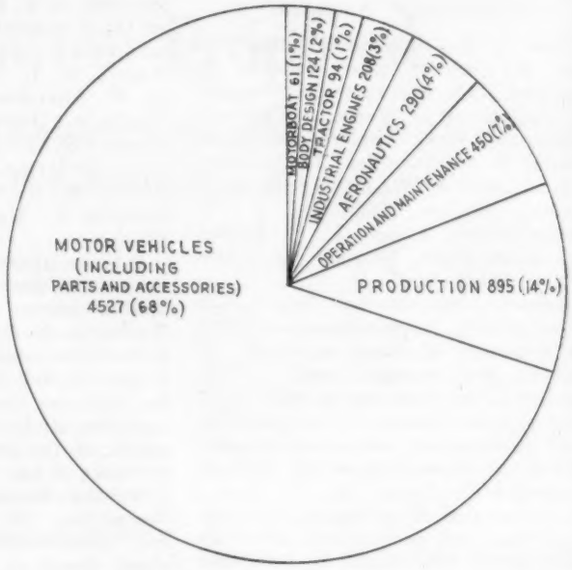


FIG. 1—COUNCIL AND DIVISION ORGANIZATION OF THE SOCIETY PROPOSED BY MEMBERS REORGANIZATION COMMITTEE


MOTOR VEHICLES (INCLUDING PARTS AND ACCESSORIES) 4527 (68%)
PRODUCTION 895 (14%)
OPERATION AND MAINTENANCE 450 (7%)
AERONAUTICS 290 (4%)
INDUSTRIAL ENGINES 208 (3%)
TRACTOR 94 (1%)
BODY DESIGN 124 (2%)
MOTORBOAT 61 (1%)

CHARTS BASED ON A TOTAL MEMBERSHIP OF 6649 AS OF MAY 1, 1928

FIG. 2—CLASSIFICATION OF MEMBERSHIP ON BASIS OF NATURE OF WORK

FIG. 3—MEMBERSHIP CLASSIFICATION BASED ON FIELDS OF PROFESSIONAL INTEREST

that can be attacked in the same way and with the same possibility of outstanding recognition. I doubt if this is likely to be accomplished, in view of the changed condition of the industry today, with our present setup.

FACTS THAT LED TO CONCLUSIONS

The following quotations from the minutes of the Sept. 5 meeting of the Reorganization Committee will be of interest in analyzing some of the conclusions reached:

Two distinct problems are involved: an executive problem and a divisional problem. In solving the first, it should be remembered that the Society owes a debt to the Societies that joined with it in 1916 and 1917, when the name was changed from Society of Automobile Engineers to Society of Automotive Engineers. We should recognize the groups adequately in any plan proposed. Under the present organization, any man, without regard to the field in which he is working, can be president. . . .

The Detroit Section has pioneered the divisional plan by organizing the Body and the Aeronautical Divisions of the Section; the Society can follow along similar lines. Success of the Detroit Divisions is due to having specialists heading the activities, these men being given the highest titles possible, that is, the head of a Division is Chairman of the Division and Vice-Chairman of the Section.

What is wanted is activity, not titles; but titles commensurate with the responsibilities involved are most desirable. No attempt has been made in the Detroit plan to decide how many or what Divisions should exist in the Society, nor how the Divisions should elect their own chairmen. . . . The secret of success is to let the Divisions run their own affairs. . . .

The existence of a First Vice-Presidency in the Society tends to limit the Nominating Committee in its choice for President. Two or three Vice-Presidencies would give the Nominating Committee a larger number to choose from in case of desired succession of a First Vice-President to the Presidency, and would not hurt any Vice-President who failed to receive the nomination. . . . No fear should exist regarding the possibility of a large number of Divisions being established, as 50 would be justified if the work warranted.

It might be well to revamp the entire Constitution for, although the Constitution is largely perfunctory and is seldom read, it is a basic document. It is based on the Constitution of the American Society of Mechanical Engineers, which is more or less common to all engineering Societies. Originally, the Council was self-perpetuating, but this was changed to the present method, the A.S.M.E. also changing. Since then the A.S.M.E. has given the voting power to all grades of member. To be specific, the Divisions should be specified in the Constitution or By-Laws, which should also state the steps in the procedure and the functions.

The idea of having the Council recognize Divisions as the demand therefor indicates to be advisable is fundamental. One Division might logically cover motor-vehicle design, production and operation, separate groups being recognized for these activities; but, while there are a few strong men who could successfully direct all such activity, it would be more successful in the long run to have separate Divisions.

Members are urged to express their opinions regarding the conclusions reached by the Committee and as to any related matters of interest. Only by obtaining a cross-section of the opinion of the membership can the Committee formulate a complete, definite recommendation for putting the Society on a foundation upon which can be built a stronger organization of maximum value to the entire membership.

Starts Season with Aeronautics

Chicago Section Hears Two Good Addresses and Appoints Committee To Learn Possibilities of an Aeronautic Division

WITH the presentation of two highly interesting and informative talks on commercial aviation and airplane maintenance, the Chicago Section got off to a good start in the new season with an aeronautic meeting at the City Club on Sept. 4. Among the 93 in attendance were many guests who are connected with aviation, including members of the South Town Aviation Club. Efforts were made by Chairman J. W. Tierney, who presided, Secretary Lee Oldfield and other speakers, at the conclusion of the discussion on the addresses, to sound out those present regarding their attitude toward forming an aeronautic division of the Section, somewhat along the lines of the Aeronautic Division of the Detroit Section, organized with so much enthusiasm last spring. About half of those present signified a desire for such a division, and a committee consisting of Lee Oldfield, E. P. Lott and L. D. Seymour, was elected, upon the suggestion of Chairman Tierney, to ascertain if enough interest exists or can be awakened to make it worthwhile to call another meeting to consider the question further.

The next meeting of the Section is to be on engines, and the speaker is to be C. A. Pierce, of the Diamond T Motor Car Co. Monthly meetings this season are to be on the first Tuesday each month, with a dinner starting at 6.30 and the technical session at 8 p. m. A new feature is to be the awarding of souvenir prizes at each meeting, the prizes being contributed by manufacturers in the automotive industry.

Operation Beginning To Pay

In introducing Mr. Seymour and Mr. Lott, of the National Air Transport, as the speakers of the evening, the chairman said that, although both "are representatives of a fly-by-night organization, their company has been able to secure the support of a great many hard-headed, clear-sighted, far-seeing business men, which indicates the future that a lot of men of affairs feel awaits this newest industry." Although the company has been organized only about two years, and has been flying the eastern half of the transcontinental air-mail route one year, it was last year just on the verge of making some money, despite the fact that it was operating only two airplanes from Chicago to New York City and loading these to only one-third capacity. Since Aug. 1, when the air-mail postage rate was reduced from 10 to 5 cents for the first ounce, he imagined, he said, that it was comfortably "out of the red."

Transportation and Communication Related

Mr. Seymour pointed out the close relation between transportation and communication, citing as illustrations the contemporaneous development of primitive animal and water transportation and of communication by signal fires and tom-toms; of the railroads and the telegraph; the motor-vehicle and the telephone; and the airplane and the radio. Dec. 17, this year, will be the 25th anniversary of the airplane; and wireless communication has been known to us during the greater part of the quarter century, he said, but it is only recently that we have learned that it is the only means by which we can hope to communicate with airplanes in flight.

He described briefly the radio beacon, or direction finder, with which experiments have been conducted at the Bureau of Standards during the last year, and said that lately a new receiver has been developed there. This is called a reed receiver and consists of two vibrating reeds mounted side by side and located so that their free ends are visible to the pilot. If the left-hand reed vibrates with the greater amplitude in response to signals from the radio beacon, it indicates that the pilot is off his course to the left; and if the right-hand reed has the greater amplitude, he is off to that side; but when they vibrate about equally, he knows he is on the course.

The company is now regularly transmitting and receiving by radio telephony on its experimental airplanes, and its greatest value will be in informing the pilots of weather conditions at their destination or landing points. "The pilot, sitting alone in his airplane above the fog, may become very anxious to know whether the fog persists at the field he is going to, whether the weather is getting worse or better, and what he may expect," said Mr. Seymour. "All sorts of things go through a man's mind when he is all alone, with only himself to depend upon. We hope that radio telephony will enable us to tell him when the fog is lifting or where there is a clear field to which he may go. Our pilots fly for hours in an airplane with nothing visible except the instrument board and, say, the first two struts of the airplane. They can fly through any weather, but cannot land without their eyes, and they cannot see in the fog." In the discussion later, Mr. Seymour said the present experiments indicate that, under bad weather conditions, with equipment the airplane can carry, 200 miles is about the maximum distance that messages can be received. The beacon is capable of transmitting for perhaps 150 miles.

Rapid Growth of Air Transport

Air transport is complementary to other transportation systems, he believes, and will not crowd out any other. On the 25th anniversary of the airplane, the air-transport systems of the world will have about six times as much "trackage" as the railroad systems had on their 25th birthday. The first commercial operation of an air-mail route in this Country began in 1926; now about 30,000 miles of commercial air-routes are covered every 24 hr. The mail transported has increased about 300 per cent, a 50-per cent increase having occurred in August of this year. Within six months, he hopes, the company with which he is associated will have a passenger service to New York City. Then it will be possible to leave Chicago at 9 a. m. and be in New York in the early afternoon. An airplane can leave New York City at noon and be in San Francisco the next afternoon.

Varied Uses of the Airplane

Some of the other commercial uses of the airplane described by Mr. Seymour are the air-taxi services operated in all the large centers in the Country, privately owned airplanes employed by large industrial companies for the use of their officials, aerial mapping, cotton-field dusting, timber ranging and forest-fire protection, oil-field service, observation of fish migration, and sightseeing service.

The regular charge for air-taxi service, he said, is 50 cents per mile, which makes the rate for each of four passengers only 12½ cents. A four-passenger private cabin-airplane powered with an air-cooled engine can be operated at a cost of 35 to 45 cents per mile. Only one out of perhaps 25 or 30 companies that last year made the experiment of operating their own craft has abandoned the plan, and did so because its plant was moved to a place where no landing-field exists. Any of the three-engine airplanes built to carry 10 or 12 passengers can be

operated at a cost of less than $1 per mile, if it is operated as a single unit by a company that does not have to carry an overhead for the air-transport alone. This brings the cost per individual passenger down to probably 7 or 8 cents per mile, and the passengers can travel both quicker and in more comfort than in any other way. The speaker predicted that this will be done more and more in the future.

In the last three or four years it has been found possible to dust 50 acres of cotton field with insecticide at a cost about identical with the cost of dusting 1 acre by the old way. Harold Harris, an ex-lieutenant of the Army Air Corps who is now operating this service, told Mr. Seymour that his company will "make a fortune if the boll weevils only hold out."

Sightseeing service is one of the most interesting, and probably will be one of the most enduring, services that the airplane offers, according to Mr. Seymour. At the Municipal Airport in Chicago several dozen airplanes that carry from one to four passengers, and, on Sundays, two multi-engined airplanes operate continuously, taking up one load of passengers after another as fast as they can.

Visioning a little of the future, Mr. Seymour, in closing, called attention to the enormous field that will open in allied industries as air transport develops. He likened the aviation industry to the automobile business, around which have been built up thousands of enterprises connected with the production and operation of motor-vehicles.

Lott Describes Maintenance

Mr. Lott's talk dealt with the details of maintenance of the air-mail airplanes in regular use. Most of the discussion was on phases of this work also. The flying equipment of the company consists of 30 airplanes, including Curtiss Carrier Pigeons and Douglas mail planes, all biplanes powered with Liberty engines, and the tri-engined Ford and Travelair, powered with Wright Whirlwind engines. In addition to servicing and inspection at each stop, any work indicated by the pilot's flight-card as necessary is done as part of the routine maintenance. From 6 to 7 man-hours are required properly to service an airplane. After about 200 hr. of flying, the airplane is considered ready to go to the overhaul shop and have the engine changed. The average life of an airplane in the service is approximately 1000 hr. before it is put into the shop to have the covering removed, the fuselage gone over thoroughly and virtually a new plane turned out. The Carrier Pigeons used on the Chicago-Dallas route went through about 1500 hr. of flying before they were sent to the shops for a major overhauling, but after the first 1000 hr. the flying speed is materially reduced and the cost of operation correspondingly increased.

Sudden increase in the volume of air mail since Aug. 1 has confronted the company with the question of the need for craft of greater load-capacity, as it is now sometimes necessary to send out the mail in two sections, which doubles the work of the ground crew.

The average life of an engine in service has not yet been determined, as no single engine has been run 1000 hr., although several have been operated about 700 and 900 hr. and, from outside appearance, seem to be good for a considerable number more. The water-cooled Liberty engines are now overhauled at the end of 200 hr. of flying instead of 100 hr., which cuts down the upkeep expense materially, as the cost of each overhaul ranges from $350 to $500.

As a result of the work and efficiency of the ground organization, it is felt that something is wrong if a forced landing caused by mechanical trouble occurs oftener than an average of 90,000 miles of flying. Until recently the average was 117,000 miles, or approximately 1170 hr. Up to a year ago, a mechanical forced landing could be expected for every 35,000 or 40,000 miles. In addition to the forced landings, about 10 delays a month at landing-fields are due to mechanical trouble. They are minor difficulties, and if a delay of more than 2 or 3 min. is caused it is recorded as a mechanical delay. Considering that 1178 stops per month are made on the regular flying schedule, it is felt that 10 mechanical delays is not a large number.

The discussion that followed the conclusion of Mr. Lott's talk consisted mainly of questions regarding details and explanatory answers by Mr. Lott and Mr. Seymour.

Motion pictures were shown of some airplane operations, and then the question of organizing an aeronautic division of the Chicago Section was presented by Chairman Tierney and discussed by Walter Martins and Mr. Buhler, of the South Town Aviation Club; E. W. Stewart, Lee Oldfield, Mr. Seymour, and Mark A. Smith.

Seattle Members To Organize a Section

THE first group meeting of Society members in the Northwest was held in Seattle on Sept. 14, at the Bergonian Hotel, 26 members being present. Robert S. Taylor, temporary chairman of the local group, reports that each member pledged full support to the work of organizing a local Section with a membership of at least 50, as required by the Council ruling with reference to the recognition of local Sections of the Society. There are at present 49 members in the territory which will be included in the Section, if organized. During the meeting, telegrams pledging Society support were received from President William Guy Wall and Secretary and General Manager Coker F. Clarkson.

Outing and Shore Dinner

Milwaukee Section Stages a Big Wet Outing and Plays Rainy-Day Golf

RAIN was the unfortunate main event of the summer frolic of the Milwaukee Section, held Sept. 14 at the Westmoor Country Club, Milwaukee. Unluckily, it rained in the night of Sept. 13 and was threatening to rain all the following morning. About noon, the sun turned in a false alarm of afternoon sunshine, but it was enough of a sure-fire alarm to induce about 40 of the gang to turn out, which Secretary Henry L. Debbink reports was a very credible showing considering the conditions. The outing was managed by Prescott C. Ritchie and J. R. Frantz.

On arrival at the Country Club, a golf tournament was begun. The incentive was a worthwhile prize-list of golf-kit bags, sweaters and other articles that had been donated by the Waukesha Motor Co., the Le Roi Co., W. S. Harley, F. M. Young, Julius J. Goetz, J. R. Frantz and C. L. Cole. But no sooner had all the players got away than it rained, real wet rain. Mere wetness did not daunt the players, however, and they continued to play through the next several showers; but, in mid-afternoon, the steady driving rain that was the aftermath of the thunder, lightning and showers compelled most of the participants to call it a day. One venturesome foursome composed of L. M. Ward, C. L. Cole, DeWitt Clausen and A. W. Kramlich was dogged enough to continue until it had finished the 18 holes.

After the wets had thoroughly dried out in the clubhouse, the drys all partook of an excellent fish dinner.

The following list of the prize awards illustrates one way of distributing prizes when a golf tournament is diluted by rain:

Low gross, 18 holes, L. M. Ward.
Low net, 18 holes, C. L. Cole.
Low gross, 9 holes, N. H. Miller.

(*Concluded on p.* 423)

Council Discusses Sections Matters

Approves Budgets at September Meeting but Defers Action on Dues—Waives Charge for "Transactions"

THE resolution of the Sections Committee of the Society presented at the Summer Meeting, which recommended that action be taken to make the Section and Society dues one charge of $20 per year to members residing in this Country, was discussed at length at the September meeting of the Council, held in Detroit on Sept. 4. The meeting was attended by President Wall, First Vice-President Strickland, Past-President Hunt, Councilors Sparrow and Wooler, and W. T. Fishleigh and O. A. Parker, nominated for 1929 Council.

The question of dues, which, if acted upon affirmatively, apparently would involve Constitutional amendment, cannot be acted upon finally until after it has been considered at two succeeding Business Sessions of the Society. Written comments from various members were considered. There is at this time marked difference of opinion as to the wisdom of putting the proposal into effect.

The Council did not take final action on the Sections Committee resolution recommending that entertainment expense of the Sections be recognized at the rate of $0.25 per person attending dinners, the total amount not to exceed $150 for one meeting. The subject will be taken up again at the next Council meeting.

Budgets of the Sections for the 1929 Section administrative year were approved, this action involving appropriating to 11 Sections upwards of $7,000 from the Treasury of the Society.

To Distribute Transactions Free

In connection with the approval of the recommendations of the Finance Committee on the financial budget of the Society for 1928-1929, the Council directed that the budget shall provide for the distribution of TRANSACTIONS without charge in addition to dues to those members requesting copies of them, beginning with Part I, 1927. This eliminates for the time being at least the additional charge of $2 per part which has been in effect for some years. The Council therefore directed that the permanent-order mailing list for TRANSACTIONS, which has been maintained for some time, be abolished.

A progress report was made on the subject of the Society issuing a cumulative index of its publications.

Society's Financial Condition

A financial statement as of July 31, 1928, was submitted. This showed a net balance of assets over liabilities of $214,155.22, this being $13,992.98 more than the corresponding figure on the same day of 1927. The gross income of the Society for the first 10 months of the fiscal year, Oct. 1, 1927, to July 31, 1928, amounted to $312,891.58, the operating expense being $305,192.88. The income for the month of July was $35,955.07, and the operating expense $30,496.44.

In the matter of the periodical auditing of the books of account of the Society, an amendment of the By-Laws was proposed for the purpose of specifying semi-annual audits instead of those heretofore directed to be made quarterly.

It was reported that the Society is administering the expenditure of funds received from the Naturaline Co. of America to defray the expense of vapor-lock research which is being conducted at the Bureau of Standards in connection with the formulating of a Government specification for aviation gasoline. The work is under the supervision of the Fuels Subcommittee of the Research Committee of the Society.

Progress reports were received on the plans and arrangements for the National meetings of the Society to be held this year as set forth in this issue of THE JOURNAL.

The Council approved the proposed changes in the Constitution and By-Laws of the American Engineering Standards Committee, including the change of name of that organization to the American Standards Association. This action was taken on behalf of the Society as a member-body of the A.E.S.C.

L. B. Case was named as a representative of the Society on the American Society for Testing Materials Committee on Specifications for Copper Alloys in Ingot Form. It was decided also to name a representative on the Sectional Committee on Standardization of Electric Motor-Frame Dimensions.

Action on Memberships

The election of 52 members, 9 grade transfers, and 3 reapprovals, on which the Council had acted by mail vote, were confirmed. Forty-six additional elections to membership were approved, as well as 11 transfers in grade of membership. Twenty-two resignations were accepted, and 26 members, who were delinquent in 1928 dues and filed resignations after Jan. 1, 1928, were dropped. Two applications for reinstatement were approved and 4 applications were reapproved. The election of 2 Affiliate Members, on whose applications the Council had acted by mail vote, were confirmed.

Wright Brothers and Manly Medals

Copies of a newly printed pamphlet giving information as to the awarding of the Wright Brothers Medal to the author of the best paper on aerodynamics or a related subject that shall be presented at a meeting of the Society or a Section during 1928 were distributed at the meeting.

In the matter of the Manly Medal Fund it was reported that this had been underwritten in an amount in excess of $8,000 by various members of the Society. It is planned to mail subscription letters to all the members within a short time, setting forth the purpose and conditions of the awarding of the Manly Medal.

Operation and Maintenance

Cleaning Practices Outlined

E. C. Wood Tells How Premises and Equipment Are Made Attractive

EMPHASIS on neat appearance of premises and equipment is a more or less recent development in operation and maintenance practice on the Pacific Coast, according to a statement made by E. C. Wood, superintendent of the transportation department of the Pacific Gas & Electric Co., San Francisco, in a paper presented before the Society on the Maintenance of Motor-Vehicles. In a portion of the paper dealing with this subject he states that this change gradually has been recognized as an advance over older methods because it tends to lower costs and to eliminate to a large extent many formerly serious fire-hazards. One reason for the improvement is the substitution of mild chemical cleaners in powdered form for the cleaning agents formerly used. The two phases of maintenance of neat appearance are those of the shop and its accessories and the servicing and reconditioning of equipment which goes through the shop.

Good condition of the shop floor is a primary factor of neatness of the premises. In most cases the floor is surfaced with concrete. Because of its porosity, oils and greases penetrate the body of the concrete and cause what may seem to be permanent discolorations. Dirt and tarry matter will accumulate on the floor until the entire surface presents an untidy appearance and creates unsanitary conditions. To overcome these conditions, the former practice was to wash the floor with a petroleum distillate. This removed the objectionable surface material, but any further attempt to clean merely caused the diluted oil and grease in the distillate to penetrate the concrete and add to the discoloration already existing. The most important objections, however, were that such practice created a serious fire-hazard and that the cost was too great.

The new method has none of the disadvantages mentioned. By the use of a correctly compounded powder, the binder which causes the tarry material to pack on the surface is broken down and is washed away with the water; then, by an additional cleaning of the surface with a solution of the chemical powder in water, the materials which have sunk into the concrete are emulsified and brought to the surface where they can be washed away with water from a hose. Finally, the chemicals bleach the concrete surface, leaving a clean white color that is pleasing to the eye. The fire hazard is eliminated because the powdered chemicals are noncombustible. The cost per gallon of a water solution of the powder ready for use for floor cleaning is but a fraction of a cent, and 1 gal. of such a solution will clean nearly 500 sq. ft. of flooring.

Cleaning Motor-Vehicles and Chassis

A tank of heated water which has in solution a non-combustible cleaning-powder has replaced the former method of using distillate for washing oil and grease from motor-vehicles and parts. The cleaning solution gives off no dangerous fumes and is so mild that an employe can dip his hands in it freely without injury; yet it removes dirt and grease from all mechanical parts and from inaccessible corners. The costs are materially less than in the former practice. Solutions strong enough to remove rapidly the heaviest deposits of dirt and grease cost only from 1 to 2 cents per gal. The use of powdered cleaners has simplified the problem of vehicle cleaning considerably.

In nearly all the larger shops, racks have been installed to facilitate the systematic washing of motor-vehicles and their equipment. A small boiler for delivering steam at pressures from 50 to 100 lb. per sq. in. is included. A small tank is provided in which to mix the powder in water, and the solution is delivered to a spray nozzle where it is mixed with steam and hot water. Thus, the cleaning of a truck chassis requires but a few minutes; the cleaner contains a small proportion of soap and a chassis can be cleaned thoroughly without damaging the painted work. The solution used in this method also costs less than 2 cents per gal.

Owing to the excessive cost of freeing metal parts from foreign deposits such as residues from cutting compounds, cutting oils and quenching mediums, by the use of solvents such as naphtha, gasoline, kerosene and the like, and because such solvents soon reach the point of saturation and become useless as cleaners, various powdered cleaners have been originated to remove such deposits without dissolving them. A suitable powdered cleaner for such usage is one that will attack and break down mechanically the binder which holds the particles together. Temperature and agitation play a very important part in cleaning when such mediums are used, because the action must be both chemical and mechanical to secure satisfactory results.

Solution Must Not Be Too Concentrated

The mistake often is made of trying to use a too concentrated solution of the cleaner. Those familiar with such problems know that caustic soda or soda salts will not affect strictly mineral oils in any way; but the mistake made is in assuming that, if the mild solution of soda salt will not do the work, a stronger solution will do it. If the cleaning powder is compounded properly so that it will effect cleaning action, the more concentrated solutions are unnecessary. The choice of a suitable cleaning powder or solution should not be determined by its price; it should be based upon its suitability and the service it renders.

COST OF CLEANING MOTOR-VEHICLES

Wash Racks Number of Vehicles, 258		Steam Plant Number of Vehicles, 156		Polishing Number of Vehicles, 50	
Labor	$247.00	Labor	$156.00	Labor	$25.00
Water	35.00	Water	35.00	Polish	8.40
Sponges	8.00	Gas	45.00	Cheesecloth	11.20
Chamois	7.00	Solution	15.00		
Soap	12.00	Boots, etc.	1.40		
Hose	3.00	Depreciation at 30 per cent and 8 per cent	25.00		
Brushes	1.50				
Aprons, boots, rags, etc.	3.50				
Total	$317.00		$277.40		$44.60
Average Cost	$1.23		1.77		0.89

In cleaning trucks before painting, a cleaning compound used successfully by several fleet operators is as follows: soda ash, 33 per cent; caustic soda, 32 per cent; trisodium phosphate, 16 per cent; silicate of soda, 12 per cent; and resinate, 7 per cent. A water solution of this acts rapidly to remove old paint and does not give off injurious or objectionable fumes. It is used before the truck is sent to the spraying room to receive the first coat of new paint.

Steam Cleaning

Modern washing-equipment has made it possible to meet the demand for clean motor-vehicles at reasonable expense and without loss of too much time. Motor-trucks are now being cleaned more regularly, because of the availability of such equipment; whereas, formerly, they were largely neglected owing to the prohibitive cost of cleaning by the hand method. An additional feature is that chassis parts which formerly were not included can now be cleaned quickly, and this has a tendency to reduce the cost of maintenance. An analysis of steam cleaning, washing and polishing of motor-vehicles for a three-month period is presented in the accompanying table.

The steam-washing rack is used also for the removal of paint. The cost of removing paint by former methods varied with the grade of paint and the number of coats. Experience with paint-removers now available shows that the cost of the material varies from $1.00 to $3.50 and the labor cost from $5.50 to $16.00; but the paint-removing plant will do this same work at a cost of 50 cents to $1.00 for cleaning solutions and the work can be done in 3 hours.

Profitable Motorcoach Fields

DISTINCTION is made between special motorcoach services that increase the volume of patronage and produce increased profit, and certain luxuries that reduce the seating capacity and necessitate charging an increased fare, in the paper entitled Development of Profitable Fields of Motorcoach Operation, by J. L. Smith, which is printed in this issue of THE JOURNAL, beginning on p. 391. According to the author, many operating companies have failed because they have not given enough consideration to this difference, and his paper analyzes the means whereby increased motorcoach business can be developed.

Garage Management

ATTENTION is called to a new book entitled Garage Management and Control, by Joseph E. Mills, a review of which will be found on p. 32 of the advertising section in this issue. Mr. Mills is a member of the Society, and is Commissioner of the Department of Purchases and Supplies, Detroit.

Motorcoach Maintenance

Inspection and Servicing Methods Followed with a Fleet of of 150 Vehicles

THE Toronto Transportation Commission began operating buses in 1921 with 5 vehicles, and today has 150 buses and coaches. From one short bus feeder-line to the railway system, the service has increased to include 13 feeder lines, 4 interurban-coach routes to Buffalo, Niagara Falls, Hamilton, Brantford and Cookstown; a city coach-service, year-round sightseeing, chartered coach-work, and the various types of special service such as race-track service. As to the distinction that the Commission makes between buses and coaches, the buses are painted red, to conform in general appearance to the street-cars, and are operated on the feeder routes for a universal fare with free transfers, while the coaches are painted gray and are operated on all other services at a special rate of fare under Gray Coach Lines, Limited.

The routine is the same in all our garages. The many varieties of service often require several consecutive allocations of a coach; so accommodation is arranged at the exits, where tire pressure, wheel nuts and water can be checked, demountable signs or run numbers changed, and extra seats added when required.

On return to the garage, the gasoline tanks are filled and the oil level checked. Each vehicle is inspected and classified for service, general inspection or repair. If for service, it is cleaned inside and out and placed in position for the next booking, when the tires and battery are checked and minor adjustments are made.

Thorough greasing is done every 1250 miles, and a general inspection is made every 2500 miles, for which the vehicles are "called" the day before. This work is done by the day staff and consists of a thorough lubrication and check-over of all working parts as well as the body. The brakes are examined and tested. The engine is cleaned and tuned. Tires are gone over for minor cuts and replaced if necessary. In fact, every effort is made here to secure uninterrupted service for the next 2500 miles. Every 5000 miles a more complete inspection is made. The inspection staff has available with each vehicle a detailed record of all trouble it has encountered since the last previous inspection. This is compiled daily from the driver's defect-reports, road calls, change-offs, delays and accidents, during the period.

These regular inspections are perhaps the most important part of the whole bus-maintenance program. I have no doubt that, as the later equipment becomes older, the general take-down and overhaul of the complete vehicle will be superseded by changes of complete unit-assemblies at the regular inspection period, depending on the serviceable age obtained for the particular unit of a type and make of bus, for any one class of service. This, of course, will require detailed systematic records of performance for all units, so that they can be classified in an endeavor to be at least one jump ahead of "old man trouble" and his faculty for interrupting service.

Standard Trouble Classification Needed

We need a standard classification of trouble. Certain standards of manufacture and design have been arrived at and agreed upon. We nearly all use a standard classification of accounts, but what constitutes a delay, a pull-in, a change-off, and interruption of service, has not been standardized. If some yardstick were set up, with free interchange of ideas between operators, and between the manufacturers and operators, logical comparisons could be made; and no doubt better service would result for the public, whose first demand is reliability.

The bodies are gone over annually, and such developments as are found desirable are incorporated. This work is followed by a repaint. The "general shops" cooperate in arriving at a schedule for the year to suit any particular seasonable phases of the business. Carpentry, upholstering, sheet-metal and blacksmith work, and painting are done by the staff, for both street-cars and buses.

The chassis-overhaul period is about 65,000 miles, or every second year, when necessary replacements are made to run a second period. The engines are changed, if spares are carried, after about 50,000 miles. Other units are changed whenever necessary. The spare units are rebuilt and stocked.

Suitable Parts Supply a Problem

Keeping a suitable supply of spare parts is always a problem. With the rapid development in design, the manufacturer can be of the utmost assistance by keeping the maintenance departments fully posted. Some manufacturers change the part number and not the model number; others change both. But if the manufacturer informs the operator that a new part-number is interchangeable with such-

and-such a part number or numbers, all should be smooth sailing. It seems to us that a sincere effort is being made by all the manufacturers to help the maintenance work of ordering and stocking parts.

We have had woven and molded brake-linings, metal shoes, and brake blocks; two-wheel and four-wheel brakes; mechanical, vacuum-booster, hydraulic and air foot-brakes; transmission and rear-wheel hand-brakes; but still our brake maintenance is the most expensive part of the program. This is, perhaps, as it should be, but undoubtedly further improvements will develop.

Brakes have an important part in the life of a tire. We brand our tires, keep individual-tire records, and do our own repairing. We use five sizes of bus tires, but eight types of wheel.

The electrical department of the Commission makes and rebuilds our batteries. All our 12-volt batteries are now interchangeable in all makes of vehicle. The only distinction we make is that batteries painted red are used on buses, black batteries being used on coaches. This, of course, is for cost-keeping purposes. Batteries are charged at the garages.

Lubrication is becoming fairly well standardized. The reclamation of crankcase oil is an established practice, the oil-reclaiming plant for the Commission being in the general shops.

The cost of bus maintenance will be reduced tremendously by standardization and interchangeability of the more frequently replaced units. But the step which helps first to this end is accessibility of each and every unit. This appears to have gained the attention of all designers.—A. S. McArthur, superintendent, garage department, Toronto Transportation Commission.

Automotive Papers at Street-Railway Convention

NUMEROUS phases of the automotive industry were included in the program of the convention of the American Electric Railway Association held at Cleveland, Sept. 22 to 28. Prosperity and the Automotive Industry was the title of a paper by C. F. Kettering, vice-president of the General Motors Corp.; and other interesting papers on special subjects were scheduled at other sessions. Among these were reports of the Accountants' Association committee on standard classification of accounts, and of the subcommittee on motorcoach accounting; a paper on auditing control in the manufacturing industry, and reports of the committees on freight accounting and on the review of accountants' proceedings.

In the session devoted to purchases and stores, two papers dealt with handling supplies for motorcoaches and what constitutes a fair measure of the cost of handling materials and supplies.

A session of the rolling-stock division included a paper on motorcoaches. At the transportation and traffic session, the effect of passenger automobiles on mass-transportation traffic and a report of the committee on motorcoach operation were two of the subjects of greatest specific interest to men in the automotive field.

National Safety Congress

Need of Enactment and Enforcement of Uniform Laws and Regulations Emphasized

UNIFORM motor-vehicle laws must be enacted and enforced throughout the United States before there will be any real reduction in the number of traffic accidents, in the opinion of the National Safety Council, which devoted a special session to the discussion of Motor-Vehicle Legislation during the Annual Safety Congress held in New York City, Oct. 1 to 5. The Congress convened after this issue of THE JOURNAL had gone to press, but some of the subjects and speakers scheduled on the program are mentioned herewith to indicate the trend and scope of the work of the Congress in its direct cooperative relation with the automotive industry.

At the special session mentioned, The Model Traffic Ordinance was to be discussed by A. C. Godward, city planning engineer, Minneapolis. This proposed new legislative document has only recently been circulated, after having been considered for many months by a committee designated by the National Conference on Street and Highway Safety, and it is hoped by the sponsors that it will be adopted universally by communities throughout the Nation. Seth T. Cole, counsel to the commissioner of motor-vehicles, Albany, N. Y., was scheduled to present a paper on Practical Pointers on Legislative Promotion; and another timely paper on Bringing Our Traffic Laws Uptodate, by Charles C. Janes, secretary of the Ohio State Automobile Association, Columbus, was listed for presentation and discussion.

A special session devoted to traffic-law enforcement was also on the program. The subjects and speakers scheduled were: Catching the Accident Criminal, by Edwin J. Barry, director of public safety, Cleveland; Getting Public Support for Law Enforcement, by Joseph T. Davis, president of the St. Louis Safety Council, and A New Procedure in Traffic-Law Enforcement, by E. B. Lefferts, of the Automobile Club of Southern California, Los Angeles.

Subjects scheduled for the traffic-engineering session were: The Value of a City Traffic Engineer to the Legislative Body, by T. J. Bowler, chairman of the committee on traffic regulation and public safety of the City Council, Chicago; Practical Means of Building Safety into the Streets and Highways, by R. L. Morrison, professor of highway engineering and highway transport, University of Michigan, Ann Arbor; and Off-Street Loading, by Percy Straus, of R. H. Macy & Co., New York City.

Among the subjects of automotive interest scheduled for discussion at another session were the making of lacquer finishes, good housekeeping for safety and production, existing safety rules, mechanical safeguarding, and safety committees. Some of the topics listed for the taxicab and fleet-owners' session were the safe driver at the wheel, the safe operation of privately owned passenger-cars in congested districts, the interfleet contest as an aid to safety, the commercial truck driver, and what constitutes safe motorcoach operation.

Production Engineering

Metal-Cutting with Diamonds

Slight Pressure and Small Wear of Tool Result in Fine and Accurate Finish

TOOLS pointed with diamonds have been used for years to dress grinding-wheels and to do cutting work in hardened steel and other materials that are too hard to be cut by steel tools. It seems to be a more recent discovery that they can be used economically in machining a number of softer materials, particularly those on which steel tools do not have satisfactory life.

Among the materials most commonly considered for machining with diamond tools are hard rubber, vulcanized fiber, ebonite, vulcanite, mica, "felt" paper-rolls, bronze, bearing metal, aluminum, copper, Monel metal, and malleable iron. All these materials are more severe in their effects upon steel turning-tools than their hardness and tenacity seem to indicate, or it is difficult to finish them smooth with a steel tool.

It is said that economical results are obtained also in turning cast iron, at least under certain conditions. For the automotive industry, it is probable that most of the interest in the application of diamond tools will be centered on their use in turning bronze and other bearing metals, aluminum alloy, copper and Monel metal, at least for the present.

The finishing of bearing-metal and bronze bushings in crankcases and connecting-rods is the best-known automotive manufacturing use of diamond tools, other than wheel-dressing tools. In this work, the radial pressure between the tool and the work is so slight that a boring-bar such as can easily be provided will not deflect enough to measurably affect the accuracy of the bearing. As a result of this, the bore is true although the amount of material to be removed may be unequal at different points. Small grooves and the cuts in a split bearing do not cause the tool to jump, and no bell-mouthed effect is caused at the ends of the bearing.

Furthermore, the tool can be run at such high speed that it is practical to take a very fine cut, this, with a marked freedom from tearing effect, making possible a smoothness of finish that can be obtained with no other known method of machining. This quality of the diamond tool is exemplified in its use in turning some of the small bronze parts of optical instruments on which a very highly polished appearance is secured without a polishing operation.

The ability of the diamond tool to pass from an "air-cut" to metal-cutting without deflection is one of the reasons for its use in turning and boring aluminum pistons and in boring cylinders of two-cycle outboard marine-engines. Commutators for automotive generators also are being turned with diamond tools, since a very smooth finish can be obtained in spite of the spaces between the commutator bars.

In turning aluminum, copper and malleable iron, the diamond tool does not tear the metal and leave it rough, as does a steel tool. Monel metal is being used for carbureter float-valves and water-pump shafts in some cars, but it is difficult to turn accurately with steel tools. The use of diamond tools has proved to be a solution of this problem with some manufacturers.

Accurate finishing rather than the removal of large quantities of stock is the greatest use for diamond tools in machining. To make the most of its ability to give a smooth finish, the feed of the tools should be small, and very high speed can be attained without damage to the tool or to the work.

Very High Speed Possible

Just how high this speed can be has not been determined definitely for many materials, but ⅞-in. bronze connecting-rod bearings are being finished with boring-bars making 5000 r.p.m. while the boring-bars for the 2½-in. bearing-metal bearings in the same rods rotate at 2500 r.p.m. The feed for this job, in which the two boring operations are done simultaneously, is 0.0025 in. per revolution of the large spindle, and the time required is 50 sec. from floor to floor. It is said that 2700 connecting-rods have been finished within a period of three weeks without adjusting the tools.

In Fig. 1, a connecting-rod is shown in place for boring both ends. A fixture for boring two big-ends simultaneously is shown in Fig. 2. In another case the piston-pin holes of two 2½-in.-diameter pistons are being bored

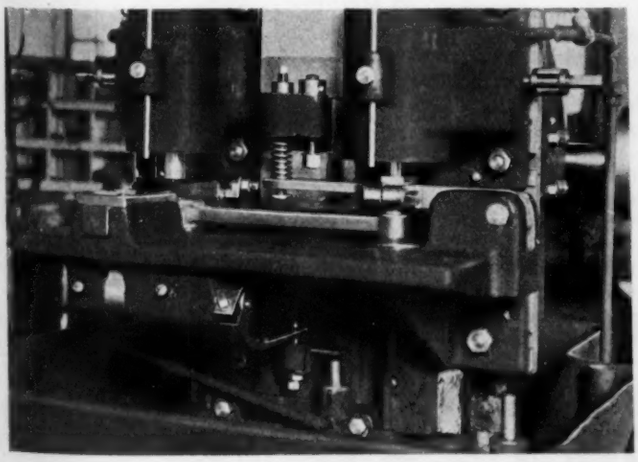


Fig. 1—Diamond-Boring Both Ends of Connecting-Rod

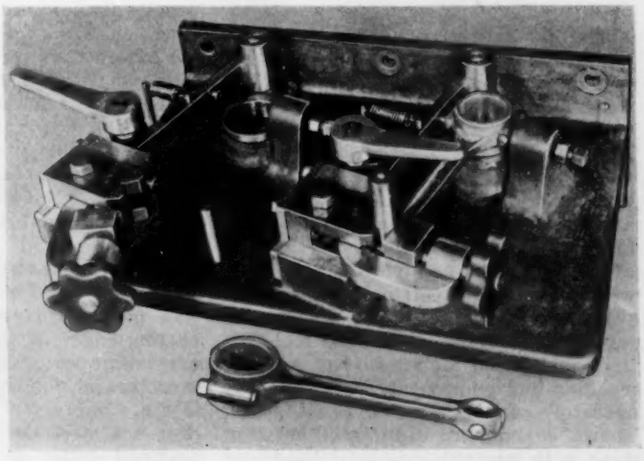


Fig. 2—Fixture for Boring Big Ends of Two Rods

simultaneously with a spindle speed of 5000 r.p.m. The gross time occupied by this operation is 50 sec. for two pistons. A set-up for a similar piston job is seen in Fig. 3. Commutators 2½ in. in diameter are being finished at 2000 r.p.m., with a feed of 0.003 in. The diameter is being reduced 1/64 in.

In many cases work is being done at the limit of speed of the machine-tool, although it might be possible that the diamond tool would operate equally well at higher speed. This probably applies to the finishing of 5/16-in.-diameter Monel-metal valves at a speed of 800 r.p.m., which is the maximum available speed of the lathe. The feed used is 0.0025 in. per revolution, and the reduction in diameter is 0.010 in. It may also apply to a certain difficult boring job in cast iron where great accuracy is required. The speed here is 850 r.p.m. in a 5-in. bore. The feed is 0.005 in. and the maximum depth of cut also is 0.005 in.

Notwithstanding the fact that the pressure between the tool and the work is less with the diamond tool than with a steel tool, great care is taken in some cases to make the preliminary finishing operations accurate, to assure accuracy in the finished work. The very slow rate of wear of the diamond is an important factor in the accuracy of the results that are attained.

New Requirements on Machines

Largely because of the requirements for high speed and small feeds beyond the limits of the present conventional machine-tools, greater application of diamond cutting-tools is waiting for the development and production of new machine-tool equipment. At least one make of machine-tool is on the market, in both one-spindle and two-spindle forms, that is especially designed for the purpose. This is the vertical boring-machine that was used in finishing the connecting-rods and pistons for which the data have been given. Other machine-tools are either on the market or under development.

The distinctive requirements for a diamond-cutting machine-tool are provisions for much higher speeds and finer feeds than for the use of steel cutting-tools. Great rigidity also is needed. Without it, the high speeds would produce objectionable vibrations that might result in inaccurate work and broken diamonds, and full advantage could not be taken of the capacity of the diamond-pointed tool to work without measurable deflection.

Possibly the greatest obstacle to the rapid introduction of diamond-tool cutting, aside from the scarcity of suitable machine-tool equipment, is the lack of operators experienced in this work. There is enough difference between work with conventional steel tools and with diamond tools so that the operator must acquire a new sense of proportion. He also must acquire a wholesome respect for the qualities of the diamond point itself, and learn to handle it with care. While the diamond will withstand abrasion better than any other known substance, as is evident from its use in truing grinding-wheels and in cutting precious stones and glass, nevertheless it is a fragile material. When set in a tool-holder, a comparatively light blow may fracture it. Too many accidental fractures of this sort will make the tool-cost excessive and cause discouragement with the process. Girls are employed almost exclusively for small diamond-turning operations by one manufacturer.

Two types of diamond are used for tool points. One form, which comes from Brazil, is a conglomeration of

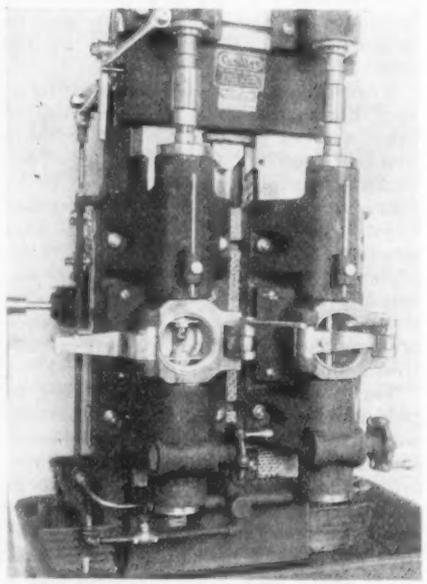


Fig. 3—Two Pistons Mounted for Boring Piston-Pin Holes

microscopic crystals. Most of these stones are black, but some are dark green, brown or yellow. The black stones are known as carbon, and often, also, as black diamonds. Because of the absence of clevage planes, carbons are less liable than borts to fracture and are said by some to be more desirable for the making of diamond bits for core-drilling in rock, the modern method of prospecting.

Borts are believed, however, to be generally used for wheel-dressing and for boring and turning-tool points. Their extreme hardness makes them more suitable for this work, and the tool points are shaped to the desired cutting-edge in accordance with the crystalline structure of the bort, which structure is not found in carbon. Bort is the name given to a diamond which does not meet the requirements of the diamond cutter as to color and structure, so that it is rejected for use in jewelry.

In the past it has been necessary for industrial users of diamonds to venture into a new field with little guidance. The stones have been bought from diamond merchants who handle the industrial diamonds as brokers, and most of the experience that has been acquired in their mounting and industrial use has been built up by manufacturers and users of diamond core-drills and of grinding machinery and wheels.

At least one firm now is specializing in diamonds for industrial purposes and maintains a laboratory for solving experimentally the problems of its customers, and a staff of service men to advise and help them.

Indebtedness is acknowledged to Harry W. Wagner, of the Koebel-Wagner Diamond Corp., New York City, for much of the information herein.

References in the Trade Press

Following are some articles on the subject that have appeared in technical publications:

Two models of the Coulter diamond-tool boring-machine were described in *Machinery;* August, 1926, p. 1001, and July, 1928, p. 867.

The use of diamonds, chiefly in finishing instrument parts in the Bausch & Lomb plant at Rochester, N. Y., is described by Charles O. Herb in *Machinery,* December, 1926, p. 241.

Something about the selection, mounting and grinding of diamonds is told by John R. Godfrey in the *American Machinist,* Feb. 10, 1927, p. 244.

Some experiences in the use of diamonds in automotive and other work is given in the discussion of a paper by O. C. Kavle in The Journal, March, 1927, p. 411.

Diamond boring of Locomobile crankcases and connecting-rods is described by N. A. Jagger in *Automotive Industries,* Aug. 13, 1927, p. 228.

Machining of connecting-rod bearings at the Wilson Foundry & Machine Co. is described in an article by C. R. Alden in *Machinery,* April, 1928, p. 596.

Standards for Tool Steels

EARLIER attempts to establish standards for tool steels resulted in failure because of the unwillingness of manufacturers to submerge the individuality of their various brands. More recently a committee of the American Society for Testing Materials has made a more successful attempt to establish for tool steels some standards that do not prescribe the details of elements as do standard specifications for other steels.

A. H. d'Arcambal, consulting metallurgist of the Pratt & Whitney Co., Hartford, Conn., is the representative of the Society on this Committee, which is designated as Subcommittee XIV of Committee A-1.

Standardization Activities

Tests for Rubber Goods

Subcommittee Making Progress Toward Standard Tests for Vibration-Absorbing Products

MECHANICAL rubber goods have been used in increasing quantities in the automotive industry during the last three or four years for bumpers, engine supports, spring shackles, torque insulators and universal-joints to absorb vibration and shock and to increase the quietness and easy-riding qualities of motor-vehicles. With this increased use, the need has developed for suitable methods of testing mechanical rubber parts. Early in 1926 the Society investigated the desirability of establishing standards for such tests and decided to undertake the work in cooperation with the American Society for Testing Materials. It was decided to organize a Subcommittee of the A.S.T.M. Committee D-11 on Rubber Products which should be responsible for the development and standardization of the desired tests. A.S.T.M. Subcommittee XVII on Rubber Products for Absorbing Vibration was authorized and organized, with L. C. Conradi, of the Spicer Mfg. Corp., serving as chairman.

A preliminary meeting of the partly organized Subcommittee was held at French Lick Springs in June, 1927, following which the Subcommittee organization was more nearly completed. A second meeting was held at Buffalo in December for a more detailed discussion of the project, at which it was recognized more fully that there is a very definite need for standard tests for hardness, compression and permanent set in mechanical rubber parts. A draft of general specifications for a hardness testing instrument was prepared and submitted to testing-instrument makers interested in this class of materials. At a meeting in New York in January of this year, arrangements were made to provide the instrument makers with standard test slabs of six representative rubber stocks to aid them in their development work.

HARDNESS DEFINED—TEST MACHINES STUDIED

The next meeting was held in Akron, Ohio, in March, at which the Subcommittee decided to define hardness with respect to rubber product as follows:

Hardness of a rubber part is defined as the depth of indentation, expressed in thousandths of an inch, by a predetermined spherical surface under a given load. The proposed testing instrument is to have a 3/32-in. ball point, a dial calibrated to read in thousandths of an inch, and a deadweight load application of 3 lb.

At the meeting of the Subcommittee at Atlantic City last June the Tinius Olsen Testing Machine Co. and P. R. Hoopes, of Hartford, Conn., each submitted an instrument for test and approval. A group of the Subcommittee members is now engaged in testing and evaluating these two instruments, and the Subcommittee expects soon to be able to recommend a standard instrument for testing the hardness of rubber.

COMPRESSION AND PERMANENT-SET TESTS

In the meantime, another group of the Subcommittee is making a survey of the compression and permanent-set tests now used by the rubber and automotive industries. It is intended that this survey shall serve as the basis for the development of standard tests for compression and permanent set.

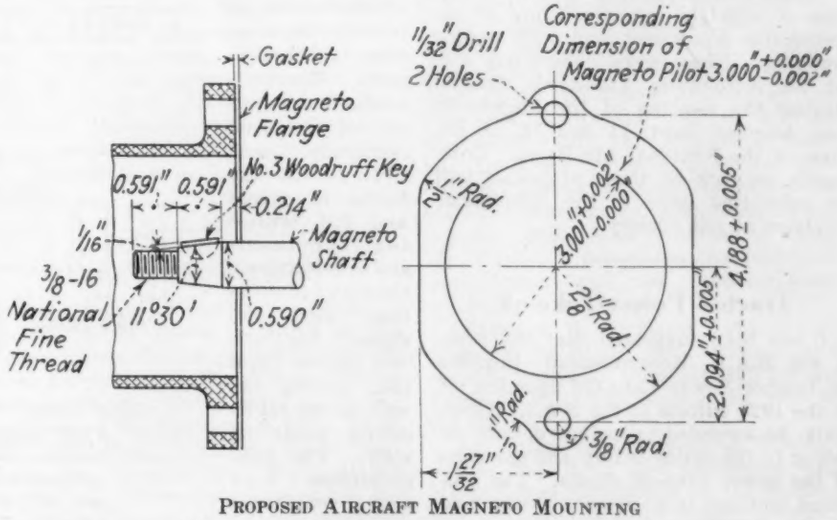
The Subcommittee is receiving splendid cooperation from the industries to which this work naturally relates and anticipates being able to report definite recommendations in the near future.

The members of the Subcommittee are: L. C. Conradi, Spicer Mfg. Corp., chairman; F. D. Abbott, Firestone Tire & Rubber Co.; A. W. Carpenter, B. F. Goodrich Co.; A. W. Holcomb, Goodyear Tire & Rubber Co.; C. Bockius, Manhattan Rubber Mfg. Co.; W. C. Keys, United States Rubber Co.; J. Kirschner, Dryden Rubber Co.; W. B. Wiegand, Binney & Smith; D. C. Scott, H. L. Scott & Co.; C. P. Thomas, Reo Motor Car Co.; A. W. Subberra, Studebaker Corp. of America; A. F. Masury, International Motor Co.; W. F. Klein, General Motors Truck Corp.; H. R. Wolf, General Motors Corp. Research Laboratories; E. Beerstecher, Dodge Brothers Co. Metallurgical Department; F. L. Lipcott, Rubber Shock Insulator Corp.; and R. K. Lee, Chrysler Corp.

Aeronautic Proposals

Two New Specifications Submitted for Consideration by the Industry

IN addition to the proposals now before various Subdivisions of the Aeronautic Division, two new dimensional standards have been offered for consideration. The standardizing of magneto flange mountings was originally suggested at the Standards Session held in Detroit last spring at the

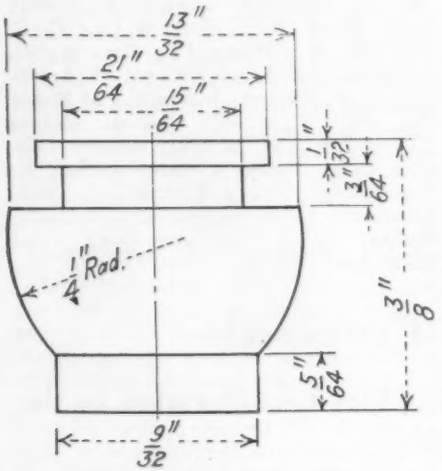


PROPOSED AIRCRAFT MAGNETO MOUNTING

time of the Aircraft Show. Although this matter is not in the hands of any Committee at present, the following specifications have been offered for consideration.

It is understood that a somewhat different design has been developed by one of the magneto manufacturers. Details of this will also be obtained and submitted to the industry for consideration before any final specifications are approved.

Although there is at present an S.A.E. Standard on a ball-type spark-plug terminal, as shown on p. 97 of the 1928 edition of the S.A.E. HANDBOOK, the suitability of this type of terminal for airplane engine spark-plugs has been questioned by Arthur Nutt, of the Curtiss Aeroplane & Motor Co. The present type being considered unnecessarily heavy, a revised ball-terminal, illustrated herewith, has been suggested for use on spark-plugs designed for aircraft engines.



PROPOSED BALL-TYPE SPARK-PLUG TERMINAL FOR AIRCRAFT ENGINES

Both of these proposals will be discussed with the manufacturers of the respective equipment and with engine builders. They were considered also at an Aeronautic Standards Session during the meeting of the Society in Los Angeles, Sept. 11 and 12, at the time of the National Air Races. Comments on both of these proposals will be submitted later to the Aeronautic Division of the Society.

Tractor Power-Take-off

IT has been suggested that the present S.A.E. Recommended Practice on Tractor Power-Take-Off Speed, p. 66 in the 1928 edition of the S.A.E. HANDBOOK, be amended to include details relating to the spline fitting and the sizes of the power take-off shafts. The proposed addition is at present a standard of the American Society of Agricultural Engineers, having been adopted by that organization and, it is stated, agreed to by all of the tractor manufacturers.

The Agricultural Power-Equipment Division of the S.A.E. Standards Committee is considering replacing the recommended practice referred to with the following standard:

TRACTOR POWER TAKE-OFF SPEED
(*S.A.E. Standard*)

The power take-off shaft on the tractor shall be provided with an S.A.E. 6B spline fitting. The straight length at the root of the spline shall be 3 in. Retaining means for securing the fitting shall not project more than 1 in. from the end of the spline.

The normal speed of the power take-off shaft shall be 536 r.p.m.—plus or minus 20—the direction of rotation to be clockwise when facing in the direction the tractor travels.

Two sizes of power take-off shaft shall be used, as follows:

(1) The 1⅛-in. splined shaft on tractors with engines developing up to 20 b.hp.

(2) The 1⅜-in. splined shaft on tractors with engines developing up to 40 b.hp.

The above ratings are based on the use of material having a minimum torsional yield-point of 65,000 lb. per sq. in.

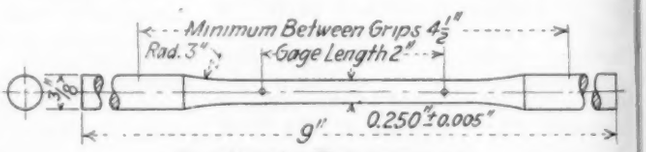
Die-Casting Alloys

Growing Use Leads to Investigation of Physical Properties and to Tests

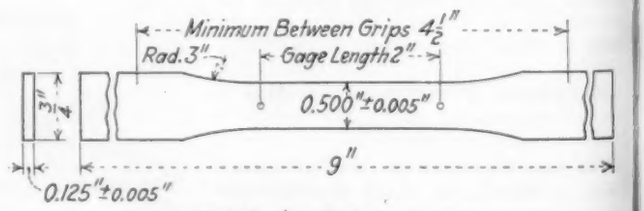
THE progress report recently issued by Subcommittee XV of the American Society for Testing Materials' Committee B2 on Non-Ferrous Metals and Alloys, describes the investigation being made of the physical characteristics of various alloys used for die-castings and their adaptability to different types of die-casting equipment and classes of product. The work was undertaken because of the growing use of die-castings in manufacture and the lack of sufficient information of this kind for their economical and correct mechanical use. A study of aluminum-base alloys was undertaken initially and subsequently extended to include zinc-base alloys. Approximately 55,000 specimens have been prepared and distributed among a number of cooperating laboratories that have reported the results of their tests up to this time on some 10,000 specimens. The tests evaluate properties of the most commonly used alloys in the forms of round and flat tension test-specimens and square impact test-specimens that were designed for the best shapes from the testing as well as the fabricating point of view. The Subcommittee has also considered standard procedure for tension, hardness and impact tests and chemical analysis. The form of test-specimens used is shown in the accompanying illustration.

It is planned by the Subcommittee that later on the study will include atmospheric corrosion and age-hardening characteristics of aluminum-base alloys, and also steam-corrosion, normal-aging and atmospheric-exposure tests of the zinc-base alloys. The Subcommittee expects to complete its report, together with tentative alloy specifications for presentation to Committee B2 within about a year for the aluminum-base alloys and about two years for the zinc-base alloys.

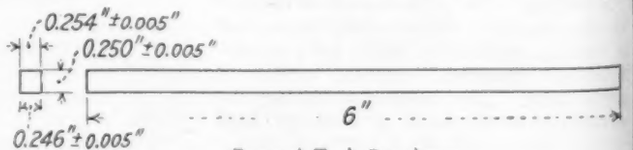
When the Subcommittee was organized in June of last year, the Society, by invitation of the A.S.T.M., appointed



Round Tension Test-Specimen



Flat Tension Test-Specimen



Impact Test-Specimen

C. W. Simpson, metallurgist of the White Motor Co., as its representative in the interests of the automotive users of die-castings.

Final Approval of Standards

RECOMMENDATIONS presented in the several Divisions of the Standards Committee and approved at the Society's Semi-Annual Meeting at Quebec in June, all of which were also passed by the Council and General Business Session at that time, were later submitted to letter-ballot of the voting members for final approval. The ballot was counted on Aug. 31, as provided for in the Standards Committee Regulations, and resulted as indicated below. Slightly fewer ballots were sent out than following the January meeting of the Standards Committee, and the return was 14.9 per cent, or not quite 5 per cent less than following the last Annual Meeting.

The new and revised specifications approved by this letter-ballot, with the exception of the Production Standards on Taps and Gages, will be ready for mailing to the members about Oct. 15.

In accordance with the decision approved by the Council early this year, the HANDBOOK will be issued only each March, in bound form, and accordingly the specifications approved as herein stated are being issued in supplementary pamphlet form that can be inserted in the 1928 issue of the HANDBOOK now in possession of the members.

A return postal card was sent to all members recently to determine, as the basis for placing our printing order, how many desire copies of the Production Standards reports. Approximately 450 members have replied and will receive copies of these reports. A limited stock of copies will be carried by the Society until the reports are exhausted or the next edition of the HANDBOOK is printed.

	Approve	Do Not Approve	Not Voting
AERONAUTIC DIVISION			
Aircraft Storage-Batteries	188	3	261
Tail-Skid Shoe Mounting	182	5	265
Castle Hexagon Nuts	200	3	249
Plain Hexagon-Head Bolts	200	4	248
Plain Hexagonal Nuts	203	1	248
Ball Hexagon-Head Bolts and Nuts	197	3	252
Eye-Bolts	199	1	252
Flat Washers	194	3	255
Pulleys, Non-Metallic	189	3	260
Rigid Terminals	189	3	260
Turnbuckles	192	3	257
Propeller-Hub Shaft-Ends	186	4	262
Generator Mountings	192	3	256
Engine-Starter Mountings	197	3	252
Fuel-Pump Mountings	169	3	260
Aeronautic Instrument Mountings	183	6	263
ELECTRICAL EQUIPMENT DIVISION			
Cable Terminals	249	1	202
Cable, Conduit and Tubing Clips	249	1	202
Flexible-Conduit Ferrules	250	1	201
ENGINE DIVISION			
Duplex-Carbureter Flanges	254	0	198
Air-Cleaner Mountings	254	2	196
Fans, Belts and Pulleys	259	3	190
Spark-Plug Tolerances	265	0	187
Motorcycle Spark-Plugs (Cancellation)	234	0	218
IRON AND STEEL DIVISION			
Sulphur Content of Steels	273	2	177
S.A.E. Steel 2320	276	1	175
S.A.E. Steel 6120	276	1	175
LIGHTING DIVISION			
Incandescent-Lamp Bases and Sockets	243	0	209
Heavy-Duty Connectors	243	0	209
Electric Incandescent Lamps	238	2	212
PASSENGER-CAR DIVISION			
Car-Frame Numbers (Cancellation)	231	0	221
Car Performance Tests	233	2	217
Plate Glass	223	0	229
Steering-Wheel Tests	237	0	215
Body Parts Nomenclature	236	2	214
PRODUCTION DIVISION			
Tool-Holder Shanks and Tool-Post Openings (Sectional Committee Report)	219	0	243
Cut and Ground Taps	225	1	226
Cylindrical Plug and Thread Gages	227	1	224
Ring Thread Gages	227	1	224
TIRE AND RIM DIVISION			
Balloon Tires and Rims	256	0	196

News of Section Meetings

(*Concluded from p.* 414)

Low net, 9 holes (tie), W. C. Klespe and O. Finsen.

Best score, 3 blind holes, DeWitt Clausen and John J. Balsom.

Three blind scores, J. U. Heuser, R. K. Winning and J. J. Goetz.

Special endurance prize, A. W. Kramlich.

A feature of future interest was the taking of about 500 ft. of standard-size motion-picture film by Mr. Ritchie, to be shown at the Oct. 3 meeting of the Section.

Brake Talk at Washington

ACTIVITIES at the Washington Section were resumed on Sept. 13 with a dinner at the Racquet Club, followed by a meeting in the evening. Chairman Thomas Neill presided at this meeting.

Discussion of brakes occupied the evening, a paper on vacuum brakes being read by H. D. Hukill, of the Westinghouse Air Brake Co., Wilmerding, Pa. Mr. Hukill's paper was illustrated with lantern slides. Following the reading of the paper there was discussion, led by H. H. Allen, of the Bureau of Standards, who has done a large amount of brake investigation in connection with his work at the Bureau.

Penn Section at Play

IN the words of Secretary Charles C. Trump, "a dozen members of the Pennsylvania Section proved themselves good executives by keeping secretaries busy while they played golf" at the fall meeting of the Section on Sept. 14 at the Tredyffrin Country Club, near Paoli, Pa. Two of the officers played tennis, and 18 members comprised the supper party, at which entertainment arranged for by Cap. Dalton Risley, Jr., included singing by Bill Mayer, assisted by members of the Section. Even more extensive and better entertainment at subsequent meetings is promised by Cap. Risley. Games of chance and other amusements occupied the evening after dinner.

Chairman A. Gelpke introduced one of the Section's new members, Carroll McShane, of the Jordan Philadelphia Co., and announced that the October meeting is to be devoted to the topic of Aviation Powerplants, on which Commander C. G. McCord, superintendent of tests at the Naval Aircraft Factory, Philadelphia, is to speak. Assistant Secretary of the Navy Edward P. Warner has promised to attend this meeting, at which Vice-Chairman J. H. Geisse is to preside.

"Nite Coach" Described

AN illustrated description of a new motorcoach-development called the "Nite Coach" was given by Dwight E. Austin, its designer, who is superintendent for the Pickwick Corp., of Los Angeles, at the dinner meeting of the Northern California Section at the Engineers Club, San Francisco, Sept. 13. Designed for both night and day highway travel, the coach embodies the essential features of a railroad sleeping-car. Numerous illustrations aided Mr. Austin in describing the details of construction and the considerations involved in the design.

Chairman S. B. Shaw outlined the proposed meetings and subjects and several inspection trips planned for the Section's activities during the rest of the season.

An outline of the work of Subcommittee No. 2 of the Operation and Maintenance Committee of the Society was presented by E. C. Wood, chairman of the Subcommittee.

Personal Notes of the Members

Clark Explains Flight Principles

An interesting addition to books on aeronautical subjects has recently appeared, bearing the title, Elements of Aviation. This book, which is commented on in the Notes and Reviews columns of this issue of THE JOURNAL, is the work of Virginius E. Clark, a Member of the Society.

Colonel Clark's interest in aeronautics dates back to 1912, five years after his graduation from the United States Naval Academy. In 1913 he was transferred at his own request from the Coast Artillery Corps to the aviation section of the Signal Corps, and the following year took a graduate course in aeronautical engineering at the Massachusetts Institute of Technology. After completing this course he was put in charge of the experimental and repair depot at San Diego, Cal., and in March, 1916, was transferred to the City of Washington, with the title of chief aeronautical engineer of the United States Army. He was appointed a member of the National Advisory Committee for Aeronautics in 1916. When the United States entered the World War he was the aeronautical member selected by the Aircraft Production Board to serve on the Bolling Mission that visited France, England and Italy.

In 1917 Colonel Clark became chief engineer in charge of airplane design at McCook Field, Dayton, Ohio, and held this position until 1920, when he left the Government service. Since that time, he has been successively chief engineer of the Dayton Wright Co. at Dayton, and vice-president and chief engineer of the Consolidated Aircraft Corp., Buffalo.

Since his election to membership in 1916, Colonel Clark has participated actively in the work of the Society. He has served many times on the Aeronautic Division of the Standards Committee and has been for several years a member of the Sectional Committee working on the Aeronautic Safety Code. In 1922 he was Second Vice-President, representing aviation engineering. While in Dayton he became a member of the Dayton Section, and upon moving to Buffalo became affiliated with the latter Section.

Colonel Clark has presented a number of papers at National meetings of the Society. In collaboration with Capt. T. F. Dodd and O. E. Strahlmann, he prepared a paper for presentation at the 1917 Annual Meeting. This paper, entitled Some Problems in Airplane Construction, was published in the December, 1916, BULLETIN and in TRANSACTIONS for 1917. Other papers by Colonel Clark were: Types of Military Airplanes, presented at the 1918 Annual Meeting and published in the January, 1918, JOURNAL and in the corresponding issue of TRANSACTIONS; Maintaining Airplane Engine Power at Great Altitudes, delivered at the 1920 Aeronautic Meeting and printed in the April, 1920, JOURNAL and in TRANSACTIONS for that year; and Air Transportation and the Business Man, presented at the 1921 Semi-Annual Meeting and published in the July, 1921, issue of THE JOURNAL.

Leighton Joins Wright Aeronautical Corp.

Lieut.-Com. Bruce G. Leighton has brought to an end his long association with the Government service to accept a position with the Wright Aeronautical Corp. at Paterson, N. J. Lieutenant-Commander Leighton entered the Navy in 1913 upon graduation from the United States Naval Academy, and during the subsequent three years he fulfilled engineering duties on the U.S.S. North Dakota and the U.S.S. Tallahassee. At about this time he directed his interest toward naval aircraft, becoming absorbed in the field of engine design. In the latter part of 1916 he was appointed shop superintendent at the Naval Air Station at Pensacola, Fla., and continued in this position until the World War, when he assumed command of the American naval anti-submarine patrol and reconnaissance in the North Sea. After the close of the war, he became identified with the Bureau of Aeronautics and the Bureau of Engineering, taking charge of the powerplant design section for all naval aircraft. During this time he also served on the Powerplants Committee of the National Advisory Committee for Aeronautics, on the Joint Helium Board of the Army, Navy and Department of Interior, and on the Sectional Committee for Aeronautical Safety Code of the Bureau of Standards. In 1927 he was appointed aide to the Assistant Secretary of the Navy for Aeronautics, and it is this position which he recently resigned.

Lieutenant-Commander Leighton, who joined the Society in 1923 as a Service Member, has become a familiar figure to those concerned with the aeronautic activities of the Society. He was a member of the Aeronautic Division of the Standards Committee in 1922 and 1923. A paper of considerable aeronautical interest, Recent Developments in Aircraft Engines in the Navy, was presented by him at a meeting of the Washington Section, and published in the April, 1923, issue of THE JOURNAL, as well as in Part I of TRANSACTIONS for that year. This paper deals with the air-cooled engine, a subject on which Lieutenant-Commander Leighton, who was actively identified with the development of the air-cooled engines now used in Navy airplanes, is a recognized authority.

Birdsall Engages in Research

Edward T. Birdsall, former president and treasurer of the Parker Rust Proof Co., Cleveland, has sold his interest in this company and will pursue research work at Hackensack, N. J. A graduate of Stevens Institute of Technology in 1886, Mr. Birdsall has been engaged in automobile designing and building since 1898. In the course of his wide engineering experience he has served various automobile companies in a consulting capacity. His connection with the Parker Rust Proof Co. was made eight years ago. In 1927 he was appointed director in charge of engineering of the Butler Mfg. Co., also located at Cleveland.

Mr. Birdsall, who sent out the notice for the meeting that resulted in the organization of the Society in 1905, was elected its first Secretary-Treasurer. In the succeeding years he has been unusually active in committee work. In 1912 he was appointed Chairman of the Meetings Committee and served as a member thereon for five consecutive years. He has at various times been a member of the Gasoline Motor Characteristics Record and the Data Sheet Divisions of the Standards Committee. Mr. Birdsall was an active participant in the organization of the Detroit Section, was elected its first Chairman in 1911, and held the chairmanship until 1916.

Two interesting technical papers by Mr. Birdsall have been published by the Society. One, entitled Some Requirements of Carbureter Design, appeared in TRANSACTIONS for 1906, and an article, Rust Prevention, was published in the July, 1919, issue of THE JOURNAL and in Part II of TRANSACTIONS for that year. In 1912 he delivered an address at the Annual Dinner, the substance of which was printed in Part I of TRANSACTIONS for 1912.

Franzen Joins Chrysler Corp.

Tore Franzen recently resigned his position as assistant chief engineer of the Detroit Steel Products Co. to join the experimental engineering department of the Chrysler Corp., of Detroit.

Since acquiring his technical education in Sweden, his native country, Mr. Franzen has been active in engineering

(*Continued on p. 36*)

Applicants Qualified

The following applicants have qualified for admission to the Society between Aug. 10 and Sept. 10, 1928. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

BAKER, ROYAL J. (J) chemist, Wadhams Oil Co., 350 Clinton Street, *Milwaukee.*

BARD, NATHAN WAYNE, LIEUT. (S M) commander Submarine Division, United States Battle Fleet, care Postmaster, *San Francisco.*

BAXTER, HOWARD (A) president, 2350 Webster Street, *Oakland, Cal.*

BECKER, ARMAN E. (M) in charge of lubrication research laboratories, Standard Oil Development Co., *Elizabeth, N. J.*; (mail) 252 Lincoln Avenue.

BERGER, MAURICE P. (F M) engineer director, Bureau de Normalisation de l'Automobile, 18 rue Tilsitt, *Paris* (17e), *France.*

CLARE, WILLIAM A. (A) vice-president, Houde Engineering Corp., 537 East Delavan Avenue, *Buffalo.*

COSNER, ROY V. (A) service manager, appraiser, Fisher-Walker Buick, Inc., 25 East Colfax Avenue, *Denver.*

DEMAREST, CORBIN Z. (A) 616 Decatur Street, *Brooklyn, N. Y.*

DISHMAN, S. R., JR. (J) United States Army, Fort Mason, *San Francisco.*

ENGLER, JOE (A) manager, 1401 11th Avenue, *Seattle, Wash.*

FORBES, DUNCAN P. (M) metallurgist, Rockford Malleable Iron Works, *Rockford, Ill.*; (mail) P. O. Box 1001.

GLASS, PHILIP A. (A) Detroit representative, Federal Bearings Co., Inc., (mail) 1121 Book Building, *Detroit.*

GRUMME, JOSEPH WILLIAM, JR. (M) specification engineer, American LaFrance & Foamite Corp., *Elmira, N. Y.*; (mail) 925 West Gray Street.

HARPER, ARTHUR C. (M) head, industrial mechanical engineering department, Pratt Institute, 215 Ryerson Street, *Brooklyn, N. Y.*

HAWN, GEORGE L., SR. (M) general sales engineer, Piston Ring Co.; (mail) 24 Henry Clay Avenue, *Pontiac, Mich.*

HESS, ERNEST E. (M) designing engineer, Lufkin Foundry & Machine Co., *Lufkin, Texas*; (mail) P. O. Box 82.

HOLADAY, WILLIAM M. (J) research engineer, engine laboratory, Standard Oil Co. of Indiana, *Whiting, Ind.*

KELLER, WILLIAM A. (A) Freyer-Brown, 2484 Milwaukee Avenue, *Chicago.*

KNOPKE, J. W. (M) body engineer, Ford Motor Co.; (mail) 2685 Oakwood Boulevard, *Berkley, Mich.*

KUEHN, OTTO (M) laboratory assistant and instructor, Armour Institute of Technology, 33rd and Federal Streets, *Chicago.*

MCBRIDE, E. F. (A) assistant to manager of purchases, manager of automotive fleet, Richfield Oil Co., A. G. Bartlett Building, *Los Angeles.*

NORDBERG, BRUNO V. E. (M) executive engineer, Norberg Mfg. Co., *Milwaukee*; (mail) 145 49th Street.

RATCLIFFE, JOHN GORDON (A) service superintendent, A. D. Gorrie & Co., Ltd., Toronto, Canada; (mail) 266 Vaughan Road, *Toronto* 10, *Ont., Canada.*

ROBSON, CLARENCE E. (M) chief equipment engineer, Edward G. Budd Mfg. Co., *Philadelphia*; (mail) 6414 North Camac Street.

RODERICK, JAMES J. (J) assistant to district engineer, Westinghouse Air Brake Co., 150 Broadway, *New York City.*

RUDOLPH, ANTHONY C. (A) sales, Bassick Co., Bridgeport, Conn.; (mail) 6050 Cass Avenue, *Detroit.*

SHAFFER OIL & REFINING CO., (Aff.) 300 West Adams Street, *Chicago.* Representatives: Fantozzi, C. T., assistant general sales manager; Majewski, B. J., vice-president in charge of sales; Miller, S. C., manager, lubrication department.

SHERWOOD BROTHERS, INC. (Aff.) 809 Continental Building, *Baltimore.* Representative: Sherwood, John R., vice-president.

SONNERDALE, JOHN (A) governing director, Sonnerdale, Ltd., 3-11 Bridge Road, *Petersham, Sydney, Australia.*

SPRING, CARL WILLIAM (A) sales engineer, lubricating oil department, Shell Co. of California, *San Francisco*; (mail) 220 Golden Gate Avenue.

SPROWLS, G. M. (M) manager, highway transportation department, Goodyear Tire & Rubber Co., *Akron, Ohio*; (mail) 909 Hereford Drive.

VICK, PRESLEY G. (A) instructor in charge, automobile mechanics department, Trade School, Hampton Normal and Agricultural Institute, *Hampton, Va.*

WARNER, TOM HENRY, (A) service manager, Long Mfg. Co., East Grand Boulevard at Cameron, *Detroit.*

WILLICH, C. FR. (F M) managing director, C. D. Magirus Aktiengesellschaft, Neutorstrasse 13, *Ulm A. D., Germany.*

YANCEY, STIRLING ROSS (A) president, general manager, Sure-Guard Corp., 578 Madison Avenue, *New York City.*

Applicants for Membership

The applications for membership received between Aug. 15 and Sept. 15, 1928, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALEXANDER, KEITH O., service engineer, Hall-Scott Motor Car Co., *Berkeley, Cal.*

BARTUSCH, ALEXANDER PAUL, mechanical engineer, Union Switch & Signal Co., *Swissville, Pa.*

BOEHNLEIN, CHARLES, assistant professor in mathematics and mechanics, University of Minnesota, College of Engineering, *Minneapolis.*

BRILL, ELKANAH H., body design draftsman, Hudson Motor Car Co., *Detroit.*

BROWN, JACK, senior draftsman, White & Poppe, Ltd., *Coventry, England.*

BRYANT, O. J., designer, Chandler-Cleveland Motor Co., Plant No. 2, *Cleveland.*

CHANLIN, W. R., draftsman, Waterous, Ltd., *Brantford, Ont., Canada.*

CHAR, ISAAC, designer, developing new equipment, American Road Machinery Co., Inc., *Kennett Square, Pa.*

COGGINS, HERBERT, supervisor of mechanical inspection, General Motors of Canada, Ltd., *Walkerville, Ont., Canada.*

DAGNER, EDWARD, factory representative, Fageol Motors Co., *Oakland, Cal.*

DITHMER, S. E., assistant production manager, General Motors Japan, Ltd., *Oshaka, Japan.*

FARAGHER, PAUL V., metallurgist, Aluminum Co. of America, *Pittsburgh.*

FELIX, FRANK CHESTER, industrial salesman, National Electric Products Corp., *Pittsburgh.*

FOSTER, JACK E., chief engineer, American Eagle Aircraft Co., *Kansas City, Mo.*

HAMLIN, FRANK B., president, Hamlin Motor Co., *Denver, Colo.*

HEUM, ALF, draftsman and engineer, Fairchild Airplane Mfg. Corp., *Farmingdale, N. Y.*

KERBY, ROY D., general manager, Durant Motors of Canada, Ltd., *Toronto, Ont., Canada.*

LAING, ROBERT ADAM, manager, The Cycle & Carriage Co. (1926), Ltd., *Kuala Lumpur, Federated Malay States.*

LEAMY, ALAN H., body designer, Auburn Automobile Co., *Auburn, Ind.*

LINSENMEYER, FRANCIS J., professor of mechanical engineering, University of Detroit, *Detroit.*

LITTLETON, JACK LLOYD, sales director, Simplex Piston Ring Co., *Cleveland.*

MILLER, DAVID R., proprietor, Miller's Brake Service, *Worcester, Mass.*

NEUNER, FRED W. C., chief engineer, Indiana Lamp Corp., *Connersville, Ind.*

PHILIPPBAR, FRANK, chief chemist and lubricating engineer, Kendall Refining Co., *Bradford, Pa.*

POPOVICI, GEORGE G., consulting engineer, Department of Agriculture, Roumanian Government Official, *Detroit.*

RAWLS, S. W., gas and oil distributor, Rawls Garage, *Franklin, Va.*

ROESCH, GEORGES HENRY, chief engineer, Clement Talbot, Ltd., *London, W 10, England.*

SCOFIELD, FRANK WILLIAM, service manager, Taylor & Smith, Inc., *Oakland, Cal.*

SHAILER, PHILIP B., factory manager, William D. Gibson Co., *Chicago.*

SHERMAN, P. A., president, Marmon South Hills Co., *Dormont, Pa.*

SINGLE, RUSSELL E., technical data section, general testing, General Motors Proving Ground, *Milford, Mich.*

SPAL, EDWARD C., spring engineer, William D. Gibson Co., *Chicago.*

STEVENS, GEORGE C., manager, St. Louis Branch, Diamond T Motor Car Co., *St. Louis.*

STEVENS, LOUIS W., superintendent, Hartford Plant, Veeder Root, Inc., *Hartford, Conn.*

THOMAS, WALTER, mechanic, Ford Motor Co., *Dearborn, Mich.*

WAKEFIELD, R. F., engineer, International Motor Co., *New York City.*

WISE, RALPH H., draftsman, International Harvester Co., *Springfield, Ohio.*

WOOD, LYSLE A., draftsman, Boeing Airplane Co., *Seattle, Wash.*

WYCKOFF, WILLIAM HENRY, engineer, Dodge Brothers Motor Co., *Detroit.*

Notes and Reviews

AIRCRAFT

Engineering Aerodynamics. By Walter S. Diehl. Published by The Ronald Press Co., New York City. 288 pp; 159 illustrations. [A-1]

This book has been written with the purpose of meeting the need for practical information on aerodynamics, presented in forms suitable for direct application by aircraft designers and advanced students in aeronautical engineering. It is an attempt to bridge the gap between the theoretical, highly advanced treatises and the elementary introductions to the study of aerodynamics.

An endeavor has been made to include as large an amount of new material as possible, and much of the subject matter is original and is now made available for the first time. Needless repetition of well-known or easily obtained data is avoided; for this reason the conventional treatment of elementary aerodynamic considerations, such as airflow patterns and pressure distributions, is omitted.

A large amount of data has been analyzed and presented in the form of working diagrams and equations, while very little space has been devoted to the descriptions of tests and test methods or to the reproduction of undigested test data. Derivations when given have been made as brief as practicable, but numerous references have been included for the benefit of those desiring more complete information.

Technique et Dessin des Moteurs Français. By J. Gaudefroy. Published in *L'Aéronautique*, July, 1928, p. 246. [A-1]

Often the half-tone illustrations accompanying engine descriptions are too obscure to make possible the distinction of much detail. The line drawings which make up the bulk of the material of this article aptly meet the desire for closer knowledge of the fine points of design. For each of the better-known French engines a series of 10 or 12 illustrations is presented, each of a section selected as of special interest and each accompanied by a brief description.

This article is one of a number of a summary or inclusive nature contained in the show number of *L'Aéronautique*.

The Formation of Ice upon Exposed Parts of an Airplane in Flight. By Thomas Carroll and William H. McAvoy. National Advisory Committee for Aeronautics Technical Note No. 293. Published by the National Advisory Committee for Aeronautics, City of Washington. 10 pp.; 2 illustrations. [A-1]

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

The formation of ice upon the wings and other exposed parts of an airplane in flight has presented a hazard that has long been appreciated. Experiences during the last year have focused the attention of the aeronautical world upon it and have brought forward a demand for more definite knowledge as to the character, the causes, and the possible means of preventing this hazard.

The National Advisory Committee for Aeronautics, at the request of the Army and the Navy, is gathering and coordinating all the information obtainable in regard to actual accident experiences and, further, has sought and examined the phenomena experimentally with some success.

In this note, the information gathered from air-mail pilots and others as to the condition, amount and shapes of ice masses formed on airplanes is summarized. Observations made with a specially equipped airplane are also reported.

Two methods for the prevention or removal of ice formation are examined. These are the heating and the greasing of the affected parts. Neither is thought to be efficacious and the recommendation is made that airplanes be equipped with means for informing the pilot of the temperature of the surrounding atmosphere so that he may avoid the combination of conditions presenting the greatest hazard.

The Zeppelins. By Capt. Ernst Lehmann and Howard Mingos. Published by J. H. Sears & Co., New York City. 329 pp.; 16 illustrations. [A-3]

In lifting the curtain on the history of the Zeppelin during the World War, the author reveals a scene of intense struggle, not solely or primarily the transient strife between opposing enemy forces, but the never-ending conflict between science and nature. To make the lighter-than-air craft useful and effective, its developers had to apply their ingenuity to combatting lightning, fog, wind and extremes of both heat and cold, as well as shrapnel, incendiary projectiles and the increasingly efficient airplane. Inexperience, too, was a large stumbling block in the path of accomplishment.

The measure of success attained, as gaged by the authors, can best be shown by the following quotations from the book: "Eighty-eight Zeppelins were launched during the conflict, each representing an improvement over its predecessor"; "improvements in design and construction were so rapid that a rigid airship was obsolescent a few months after going into commission"; "the flight [to Africa and return] demonstrated conclusively that long-distance airship transportation was then technically solved."

The book is personal, largely the experiences of one of its authors, Capt. Ernst A. Lehmann, a naval architect who joined Count Zeppelin's staff early in 1913, captained Zeppelins prior to and during the war, and is now assistant manager of the Zeppelin organization, which is at present completing its 117th airship. Captain Lehmann's notes are supplemented by personal narratives of other Zeppelin commanders and by official records of the German and Allied governments; all this material being welded into a chronological story of airship operations on the various fronts. The story is told in a non-partisan spirit and is fully as much the annals of a vehicle perhaps destined to play an important part in commerce as it is a thrilling war story. The improvements made in the airships were largely designed to strengthen them against the vicissitudes of the weather, and the technical development brought about by the war, though forced, retains its value as a permanent peacetime possession.

Elements of Aviation. By Virginius Evans Clark. Published by The Ronald Press Co., New York City. 193 pp.; 24 illustrations. [A-3]

This elementary book is of a somewhat different nature than those usually included in this category. It is not intended to satisfy the curiosity of the general reader but to acquaint the novice in aeronautical engineering or operation with the fundamentals of his

(*Continued on next left-hand page*)